Training Report

AfricaYam / RTBfoods Training on Yam Quality Evaluation

Abomey-Calavi, Benin, 22-26 November 2021

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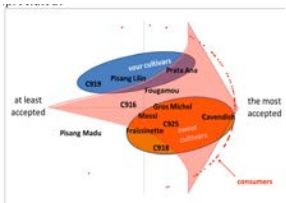

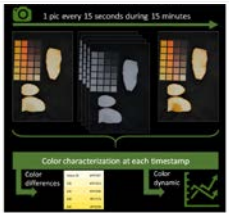

This report has been written in the framework of RTBfoods project.

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

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In memory of our colleague, Geneviève Fliedel (CIRAD).

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ABSTRACT

Given adequate disease resistance and production yields, many studies show that varietal adoption of new yam genotypes depends mainly on organoleptic quality and their suitability for processing into ready-to-eat foods. The AfricaYam project is mainly focused on varietal creation, and the RTBfoods project on the quality of RTB-based processed foods. The two projects, funded mainly by the Bill and Melinda Gates Foundation (BMGF), decided to set up a training course on the perception and evaluation of yam quality corresponding to the preferences of boiled and pounded yam consumers. A fruitful exchange between the breeders of the AfricaYam program and the socio-economists and technologists of the RTBfoods program was made possible by the organization of a seminar at the Faculty of Agronomic Sciences (FSA) of the University of Abomey-Calavi (UAC) in Benin, in November 2021.

The yam quality evaluation workshop provided an opportunity to compare yam breeders' practices with the methodologies developed by the RTBfoods project to evaluate yam quality in relation to consumer perception. It included presentations on both field studies to capture priority traits from consumers and stakeholders, and on implementing new medium- or high-throughput laboratory analyses to assess these quality traits and participatory evaluations with consumers, in order to validate the new laboratory analyses. Practical workshops for trainees on sensory analysis, textural measurements of boiled yam, and spectral and image analysis were also conducted. The training was greatly appreciated by all participants and allowed for extensive discussions with the breeders for the implementation of new analyses within the yam breeding pipeline. Selection based on yam (and other RTB) cultivar qualities for processing and consumption allows for significantly greater varietal adoption by producers, in addition to reducing the number of elite clones needing to be evaluated in participatory approaches.

Key Words: Yam quality evaluation, Demand-led breeding, Biochemical analysis, Texture, Sensorial analysis, High Throughput Methods, NIRS, Hyperspectral camera, Consumer perception, Varietal adoption

EXECUTIVE SUMMARY

This report provides a synthesis of the RTBfoods/AfricaYam Training on Yam Quality Evaluation as part of the outcomes of Bill and Melinda Gates-funded projects 'RTBfoods: "*Breeding RTB products for end user preferences*" https://RTBfoods.cirad.fr/ and AfricaYam*: Enhancing Yam Breeding for Increased Productivity and Improved Quality in West Africa"* https://africayam.org/.

Over 5 days, 30 trainees (50% female) from 23 partner institutes, attended the workshop. The objective of this training was to strengthen the skills of the AfricaYam breeding program teams to integrate new quality traits into their improvement schemes.

More than 300 million people, many living below the poverty line, in developing countries depend on root, tuber and banana (RTB) crops for food and income. Yams are one group of the RTB starchy tubers produced by about 600 known *Dioscorea* species (Obidiegwu & Akpabio, 2017). According to the IITA-led AfricaYam project, *more than 54 million tons of yams are produced in Sub-Saharan Africa annually on 4.6 M Ha. Over 95% of this production lies in a five-country "yam belt" that includes Nigeria, Benin, Togo, Ghana, and Côte d'Ivoire.* Nigeria's annual production of 50 million MT, accounts 68% of global Africa production (FAOSTAT,2020) but the importance of yam in the diet of West Africa and some Central African countries is substantial, with in order of importance: Côte d'Ivoire, Benin, Ghana, Nigeria, Central African Republic, Togo, Gabon, with a consumption of : 194; 161; 155; 101; 87; 71; 64 Kg/capita/year respectively (Dufour *et al.,* 2021) https://doi.org/10.1111/ijfs.14911. Of the eight principal cultivated species in west Africa, white or Guinea yam (*D.rotundata* poir) and water yam (*D. alata*) are the most important. Yam is a major and preferred staple food for over 300 million people in west Africa (Alabi et al.,2019). It provides a source of calories from carbohydrates, protein, dietary fiber and micronutrients (Asiedu & Sartie, 2010; Apara, 2013). Yam is also intimately linked with West African socio-cultural life (IITA, 2004; Obidiegwu & Akpabio, 2017). Pounded yam is a glutinous dough prepared by peeling, boiling, pounding and kneading yam tubers (Otegbayo et al., 2005).[1] *Although yam production in Africa is 38% that of cassava, the value of yam production exceeds all other African staple crops and is equivalent to the summed value for the top three cereal crops (maize + rice + sorghum). Yam is the preferred staple food in West Africa and elastic demand is constrained by inadequate production and losses in storage.*

Traditionally, genetic improvement has aimed at addressing productivity constraints and seizing opportunities for expanding the markets. Important traditional traits for breeding include yield, tuber quality, and resistance/tolerance to diseases (yam mosaic virus and anthracnose) and nematodes. However, yam breeding is challenging, there is limited (but growing) current Yam-breeding capacity in West Africa, and relatively little has been done to date.

The Gates-funded RTBfoods project has identified several key **user-preferred quality traits** for both boiled and pounded yam that have not been traditionally included in breeding pipelines. These include color and textural quality followed by taste and aroma which are lesser attributes. This information will be useful in determining food-quality indicators that can be used to select breeding lines for preferred quality traits in pounded yam. The RTBfoods project has also developed new participatory varietal selection (PVS) and high throughput phenotyping tools to assist characterization and breeder selection for user-preferred traits.

The AfricaYam and RTBfoods projects have joined forces to offer a training program dedicated to the evaluation of yam quality for use by breeders. The University of Abomey Calavi (UAC) hosted and helped organize this training, which took place between November 22 and 26, 2021, in Cotonou. The workshop was first piloted by Noël Akissoé and his team at UAC/FSA-Benin.

The program included two theoretical days that presented the approach and methods developed, adapted and implemented within the RTBfoods project to study the quality of yam tubers. This was

[1] from Otegbayo, B., Madu, T., Oroniran, O. & al. (2021), End-user preferences for pounded yam and implications for food product profile development. Int J Food Sci Technol, 56(3). https://doi.org/10.1111/ijfs.14770

followed by a two-day practical workshop, in the UAC-FSA laboratories, that demonstrated the standardized laboratory protocols for the preparation and cooking of samples, and for their sensory and textural characterization, in particular. This hands-on workshop also presented the potential of infrared spectrometry and image analysis to predict quality traits of boiled yam. A day-trip on Lake Nokoué punctuated the week, to provide participants with a contextual snapshot of yam in village life and culture, and strengthen links between project stakeholders.

The project management unit established an online, pre-meeting toolbox, including pre-recorded presentations on project progress in individual work-package and thematic areas. The website also provides access to Yam product profiles developed within the RTBfoods project. PMU encouraged meeting participants to digest these before the meeting.

The report also captures essential exchanges between trainees and trainers, and perhaps more critically between food scientists and yam breeders, who come together for the first time in such a workshop. The workshop presentations, Q&A sessions and panel discussions stimulated dynamic and useful exchanges on a wide range of yam quality evaluation issues. These covered surveys; sampling; sample preparation; data collection; laboratory analysis; data analysis and interpretation; specific quality traits; selection and breeding. These are reported in detail section 2, and highlighted as recommendations in section 5.

Participants reaffirmed their commitment to producing a set of standardized user-friendly yam-quality evaluation protocols for an agreed set of key traits, across a wide range of cultivars, in addition to accommodating user preferences. These are based on objectively-collected, robust and triangulated data, the research for which integrates contributions from food scientists, breeders and social scientists. Future smart experimental designs should integrate where possible single poly-instrumental, experiments quantifying multiple textural parameters for key trait proxies, using well- and regularly-trained multi-disciplinary teams, who can apply the required technical competencies for quality evaluation (including data analysis and image production). This requires adequate human and other resources, including time, where funding should equitably consider food quality with crop performance, and other collaborators such as universities.

RTBfoods is leading a new approach through an innovative platform moderating a new orientation towards quality evaluation, where quality thresholds will correlate well with crop performance. This approach is removing the traditional barriers between the two silos of breeding and food science, engendering mutual respect and a collaborative ethos.

Key partners for yam and other RTB quality evaluation should propose further interactions including roundtables, webinars, lectures symposia, and workshops involving a broad range of stakeholders, especially food and social scientists, and breeders. A key outcome of such interactions would be a joint follow-on RTB/Yam quality evaluation project that further promotes adoption of improved yam cultivars at scale. Collaborators would need to agree on how to improve the research domain operations and develop common aims.

Section 4 provides a summary of the workshop evaluation by participants, which successfully achieved its objectives, even exceeding expectations. The evaluation corroborates the positive feedback already received, that meeting participants were largely extremely satisfied or satisfied, and regarded the training as relevant to their needs. Feedback on relevance, learning level, next steps and miscellaneous comments is also summarized.

ACKNOWLEDGEMENTS

The meeting was undertaken as part of RTBfoods and AfricaYam projects, with the support of the Bill and Melinda Gates Foundation (BMGF) and the CGIAR Research Program on Roots, Tubers and Bananas (RTB) supported by CGIAR Trust Fund contributors[2]. The Programme Management Unit (PMU) also acknowledges the co-funding support of CIRAD, INRA, the Bioversity-CIAT Alliance, CIP, and JHI.

The organizing team acknowledges the research contributions from the AfricaYam & RTBfoods researchers and their institutes, whose work will collectively help to encourage increased adoption of improved Yam varieties in sub-Saharan Africa, thereby helping to strengthen regional food and nutrition security and agricultural livelihoods, and reduce poverty.

We would also like to acknowledge the individual members of the organizing team behind this meeting, Dominique Dufour, Eglantine Fauvelle, Cathy Méjean and Pascale Lajous (CIRAD), Alexandre Bouniol (UAC-FSA/CIRAD), Noël Akissoe, Laurent Adinsi, Laurenda Honfozo, Ignace Ogni, Imayath Djibril Moussa and Francis Hotegni (UAC-FSA), Patrick Adebola, Asrat Amele and Richard Ofei (IITA) without whose initiative this important collaborative and knowledge-sharing event may not have occurred.

We would also like to thank Dr Michael Friedmann for his/her review and for providing the Preface.

Finally, we would like to acknowledge the valuable input of Vincent Johnson (ex-Alliance Bioversity International-CIAT), of GQ International, who took the meeting notes and compiled and wrote this meeting report. Note-taking was also provided by Dr Ayetigbo Oluwatoyin, and Dr Amos Asiimwe.

[2] see: https://www.cgiar.org/funders/

ACRONYMS

AR4D	Agricultural Research for Development
BMGF	Bill and Melinda Gates Foundation
BTI	Boyce Thompson Institute
CARBAP	Centre Africain de Recherche sur Bananiers et Plantains
CATA (test)	Check all that apply testing
CIAT	International Tropical Agricultural Research Centre
CIP	the International Potato Center
CIRAD	the French Agricultural Research Centre for International Development
CNRA	Centre National de Recherche Agronomique
CoP	Community of Practice
CRP	CGIAR (global) Research programme
DMC	dry matter content
FAO	(UN) Food and Agriculture Organisation
GXE	Genotype by Environment
HSI	Hyper-spectral imaging
HTPP	high-throughput phenotyping protocols
IITA	the International Institute of Tropical Agriculture
INRAe	the French National Institute for Agricultural Research
JAR (test)	Just about right testing
JHI	the James Hutton Institute
MTPP	Medium-throughput phenotyping protocols
NaCRRI	National Crops Resources Research Institute
NARL	National Agricultural Research Laboratories, Uganda
NARO	National Agricultural Research Organisation
NIRS	Near Infrared Spectroscopy Spectra
NRI	the Natural Resources Institute University of Greenwich
NSPs	non-starch polysaccharides NSPs
One CGIAR	The restructured CGIAR global research network
PME	pectin-methyl-esterase
PMU	Programme Management Unit
PVS	Participatory varietal selection
QDA	Quantitative descriptive analysis
RMSEs	root mean square errors
RTB	Roots, Tubers and Bananas
SOP	Standard Operating Procedures
TRICOT	triadic comparison of technologies
UAC/FSA	Abomey-Calavi University- Faculty of Agronomic Sciences
VUE	variety (V); user (U); and socio-economic environment (E)
YEIB	Yam Excellence in Breeding (platform)

PREFACE

At the CGIAR Research Program on Roots, Tubers & Bananas (RTB), we are delighted with the progress in the RTBfoods project which we see as an integral and key part of RTB. When RTB began we had very little work in the post-harvest area and we've been delighted to team up with CIRAD and tap into their core skills in this area as part of the programme. Over the last two decades RTB has invested in developing improved varieties for RTB crops, and supported research to enhance the dissemination of their planting material, address challenges from biotic and abiotic stresses, improve postharvest uses and contribute through all this to improved livelihoods. However, it became increasingly apparent that the quality traits of RTB crop varieties play a central role in their adoption, and thus their positive impact on livelihoods of both smallholder farmers and processors, and on rural and urban consumers. Tools and assays to select for quality traits in a high throughput manner are not widely available and are urgently needed to help breeders select genetic material that provides the quality that farmers, processors and consumers require and demand. Breeders mostly select for agronomic traits and higher yield and may test for consumer acceptability near the end of the breeding cycle, when it may be too late to give consumers what they want. By enabling breeders to select for quality traits early on, the knowledge and the tools developed by the RTBfoods project will lead to accelerated adoption of improved varieties. Consequently, this Yam quality evaluation training provides skills, tools and knowledge for breeders and food and social scientists to work together in developing a pipeline of improved Yam cultivars that meet the needs and preferences not only of growers but also of processors and consumers. Some of the tools and knowledge are described within the publication of the open access special issue of the International Journal of Food Science & Technology (IJFST), published in March 2021. The advances in the RTBfoods project and their wide applicability across RTB crops, with many national partners, have led to the work being listed as one of the RTB Golden Eggs, a set of collective knowledge assets through the RTB partnership collaboration (https://www.rtb.cgiar.org/golden-eggs/).

Another critical aspect is the significant role that women play in the production and processing of RTB crops, including Yams. The progress shown in understanding the needs and preferences of women for the quality of the crop, both of the raw and cooked food products, as well as developing the methodology to research these issues, will help ensure the results of this project and the research efforts of the RTB program, will contribute to improved gender equity.

As the methodologies become mainstreamed in Yam breeding programs, these will be incorporated at different stages of selection, early testing of promising varieties, and final validation of those selected for release, thus reaching other stakeholders in the development, release and dissemination of improved varieties. At RTB, we believe that these will have a wide applicability for improved breeding strategies across the One CGIAR going forward. We look forwards to continuing progress and high throughput assays emerging from RTBfoods.

adapted from *Michael Friedmann, RTB Senior Science Officer, the International Potato Center (CIP)*

This report provides a synthesis of the RTBfoods West African Yam quality evaluation training workshop 2021, convened by CIRAD, within the Bill and Melinda Gates-funded project '*Breeding RTB products for end-user preferences*'

The report sets the research context. Section 1 provides an overview of RTBfoods and articulates the meeting outline and objectives. Section 2 summarizes the workshop session reports for all five work packages, of what has been achieved within the third project year (period 3), and cross cutting issues, along with a synthesis of the session discussions. Section 3 synthesizes the workshop evaluation feedback. Section 4 articulates the recommendations and next steps for Yam Breeders in the participating countries and beyond.

1 INTRODUCTION AND MEETING OUTLINE

This report provides a synthesis of the RTBfoods/AfricaYam Training on Yam Quality Evaluation as part of the outcomes of Bill and Melinda Gates-funded projects 'RTBfoods: "*Breeding RTB products for end user preferences*" https://RTBfoods.cirad.fr/ and AfricaYam*: Enhancing Yam Breeding for Increased Productivity and Improved Quality in West Africa"* https://africayam.org/.

1.1 RTB background

More than 300 million people, many living below the poverty line, in developing countries depend on root, tuber and banana (RTB) crops for food and income. These are some of the most important staple crops in the world's poorest regions and comprise bananas (including plantains), cassava, potatoes, sweetpotatoes, **yams**, and tropical and Andean roots and tubers. They provide around 15% or more of the daily per-capita calorie intake for more than 700 million people living in the least developed countries. Often rich in key nutrients such as provitamin A, RTB crops can significantly improve nutrition and food security. Many RTB crops can be grown with few inputs and often under harsh conditions. Yet they respond well to intensification and are high yielders in terms of calories produced per hectare. As important cash crops, they can help boost family incomes and are frequently grown or marketed by women. Improving their quality traits will further boost their consumption and associated livelihoods and food and nutrition security.

1.2 The RTBfoods project

Figure 1 RTBfoods project design

Breeding RTB products for end-user preferences (RTBfoods) is a Bill and Melinda Gates Foundation (BMGF) investment, which is co-funded by CIRAD, INRA, CIAT, CIP, and JHI, to encourage increased variety adoption of root, tuber, and banana (RTB) crops in sub-Saharan Africa (SSA). It is developing high-throughput tools to help breeders select RTB varieties that more effectively meet end-users' requirements, thereby contributing to greater variety adoption and improved food security. The investment is identifying the quality traits that drive users' adopting new RTB varieties, and directly

engages an innovative combination of consumers, processors, and researchers. The project is developing RTB product profiles and translating these into market-led breeding initiatives that will develop new, end-user–focused, RTB varieties in SSA. The project will improve genetic insights into the quality traits along the value chain essential for successful RTB breeding and variety adoption. Multidisciplinary teams of social scientists and food technologists will capture these essential quality traits through surveys conducted with RTB crop users (i.e., processors and consumers), farmers, traders, and middlemen.

Research activities are organized in five work packages (WPs- see figure 1) that bring together the skills and expertise of several world-class laboratories:

WP1: Understanding the drivers of trait preferences and the development of multi-user RTB product profiles.

WP2: Biophysical characterization of quality traits.

WP3: Developing high-throughput phenotyping protocols (HTPPs).

WP4: Integrated end-user–focused breeding for varieties that meet users' needs

WP5: Gender-equitable positioning, promotion and performance.

A sixth WP is dedicated to the management, financial and scientific coordination, monitoring, and promotion of the project achievements.

1.3 The importance of Yams in West Africa

Yams are one of the RTB starchy tubers, produced by as many as 600 known *Dioscorea* species (Obidiegwu & Akpabio, 2017). According to the IITA-led AfricaYam project, *more than 54 million tons of yams are produced in Sub-Saharan Africa annually on 4.6 M Ha. Over 95% of this production lies in a five-country "yam belt" that includes Nigeria, Benin, Togo, Ghana, and Côte d'Ivoire*. Nigeria's annual production of 50 million MT, accounts 68% of global Africa production (FAOSTAT, 2020) but the importance of yam in the diet of West Africa and some Central African countries is substantial, with in order of importance: Côte d'Ivoire, Benin, Ghana, Nigeria, Central African Republic, Togo, Gabon, with a consumption of: 194; 161; 155; 101; 87; 71; 64 Kg/capita/year respectively (Dufour et al., 2021) https://doi.org/10.1111/ijfs.14911. Of the eight principal cultivated species in west Africa, white or Guinea yam (D. rotundata poir) and water yam (D. alata) are the most important. Yam is a major and preferred staple food for over 300 million people in west Africa (Alabi et al., 2019). It provides a source of calories from carbohydrates, protein, dietary fiber and micronutrients (Asiedu & Sartie, 2010; Apara, 2013). Yam is also intimately linked with West African socio-cultural life (IITA, 2004; Obidiegwu & Akpabio, 2017). Pounded yam is a glutinous dough prepared by peeling, boiling, pounding and kneading yam tubers (Otegbayo et al., 2005). Although yam production in Africa is 38% that of cassava, the value of yam production exceeds all other African staple crops and is equivalent to the summed value for the top three cereal crops (maize + rice + sorghum). Yam is the preferred staple food in West Africa and elastic demand is constrained by inadequate production and losses in storage.

Traditionally, genetic improvement has aimed at addressing productivity constraints and to a lesser extent on seizing opportunities for expanding the markets. Important traditional traits for breeding include yield, tuber quality, and resistance/tolerance to diseases (yam mosaic virus and anthracnose) and nematodes. However, yam breeding is challenging, there is limited (but growing) current Yam-breeding capacity in West Africa, and relatively little has been done to date.

The Gates-funded RTBfoods project has participatorily identified several key **user-preferred quality traits** for both boiled and pounded yam that have not been traditionally included in breeding pipelines. These include color and textural quality followed by taste and aroma which are lesser attributes. This information will be useful in determining food quality indicators that can be used to select breeding lines for preferred quality traits in pounded yam. The RTBfoods project has also developed new participatory

varietal selection (PVS) and high throughput phenotyping tools to assist characterization and breeder selection for user-preferred traits.

1.4 Meeting objectives, participation and training scope

The AfricaYam and RTBfoods projects joined forces to offer a training program for evaluating yam quality for use by improvers. The University of Abomey Calavi (UAC), Faculty of Agronomy (FSA) hosted and helped organize this training, which took place between November 22 and 26, 2021, in Cotonou. The workshop was first piloted by Professor Noël Akissoé and his team at UAC/FSA-Benin.

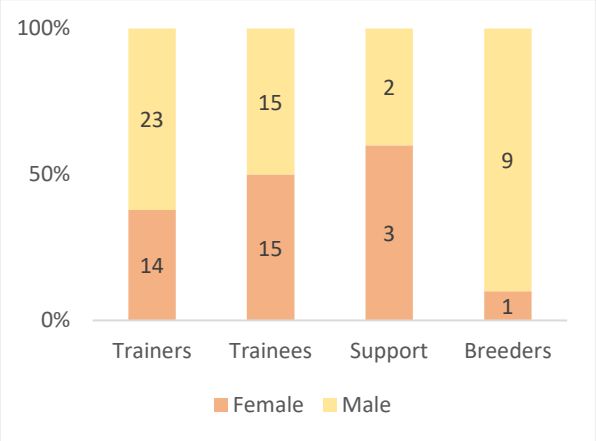


Figure 2 Yam Training participants gender disaggregation

With the **overall goal** of eventually boosting adoption of more-preferred Yam varieties, in an atmosphere of shared learning, the training's main **objectives** were to:

i) Strengthen the skills of the AfricaYam breeding program teams to integrate new quality traits into their Yam improvement schemes, through building capacity for yam quality evaluation.
ii) Share knowledge about pounded and boiled yam, including processor and consumer preferences
iii) Further strengthen the RTBfoods team spirit amongst project partners, especially with regard to forging closer collaborative links between breeders and food scientists.

Over five days, 30 trainees (50% female), 37 trainers (14% female) and some support staff representing 23 partner institutes, from 10 countries (mostly West Africa, plus France and Latin America) attended the workshop (see participants' list in annex 5.2). Ten yam breeders (10% female) formed part of the training panel, along with 27 food and other scientists (see figure 2). This evident male bias in breeding needs eliminating.

The program (see annex 5.1) included two theoretical days that presented the yam quality evaluation approaches and methods developed, adapted and implemented within the RTBfoods project five work-packages. This was followed by a two-day practical workshop, in the UAC-FSA laboratories, that demonstrated the standardized laboratory protocols for the preparation and cooking of samples, and for their sensory and textural characterization, in particular. All presentations and exercises were interspersed with moderated questions and answer sessions and panel discussions. This hands-on workshop also presented the potential of spectrometry and image analysis to predict quality traits of boiled yam. A day-trip on Lake Nokoué punctuated the week, providing participants with a contextual snapshot of yam in village life and culture.

The project management unit established an online, pre-meeting toolbox, including pre-recorded presentations on project progress in individual work-package areas, thematic areas. The website also provides access to Yam product profiles and other Yam resources developed within the RTBfoods project. PMU encouraged meeting participants to digest these before the meeting.

2 MEETING SESSION REPORTS AND DISCUSSIONS

2.1 Workshop opening session

The presentations for day 1 can be accessed here.

Professor P. Laleye, Dean of the University of Cotonou's Faculty of Agronomy (FSA) **welcomed participants** from Africa, Europe and Latin America, on behalf of its AR4D mandate. He acknowledged the joint participation from RTBfoods, and the Africa Yam projects, and reminded participants that, as the 'queen of foods', Yam is implicated in many aspects of West African life. He welcomed this initiative to equitably deliver the best cultivars for all stakeholders from breeders to consumers, considering yield, quality and climate resilience. **Prof Emmanuel Chamba**, Ghana's AfricaYam coordinator, echoed Prof Laleye's opening remarks, emphasizing promising research results to date in the two-phase programme in Benin, Nigeria and Côte d'Ivoire. **Dr Dominique Dufour** of Cirad, France and RTBfoods project management unit (PMU), reminded delegates this training was the fruit of discussions starting in 2018, to bring the RTBfoods and AfricaYam projects together. Although delayed by the Covid 19 pandemic, finally stakeholders have a great opportunity to share knowledge about pounded and boiled yam for adoption of preferred varieties, and for capturing trait preferences in the spirit of open learning. The organizing team were acknowledged for their input.

In welcoming delegates, **Professor Noël Akissoé** of UAC/FSA then provided a **useful overview on UAC regional yam research projects**, including INCOYAM (1998- 2003) amongst others, focusing mostly on quality traits of taste, texture, storage, and color, using many tools including surveys. Key traits included elasticity, mealiness, firmness, stickiness, and smoothness (grouped by use e.g. chips). He outlined some GXE and agronomy work, and research on the influences of: i) phenol and sugar content on taste, ii) starch on swelling power, iii) cell-walls on texture, and iv) nitrogenous fertilizer use plus storage on poundability.

Although invited, the French Ambassador and FSA Rector were unable to participate in the opening session. **Dr Eglantine Fauvelle** of Cirad, France representing the RTBfoods PMU acknowledged UAC training host Professor Akissoé and his organizing team. She then **outlined the training programme** of 2-days' theory, 2-days' practice and day field trip, as described above and in annex 5.1. She reminded participants the training aims to i) share knowledge, methods and tools for evaluating yam cultivar traits for boiling and pounding, and ii) provide a brief introduction from sampling to preparation to lab analysis, including infrared spectroscopy. Participants then engaged in a pairing-up familiarization exercise.

Project leaders provided respective **overviews of the RTBfoods** and **AfricaYam projects**, clearly illustrating their complementarity and potential for synergies. Dr Dufour asserted that after 4 years of significant progress, RTBfoods (2017-2023) will deliver **new traits for breeding** within this multi-RTB crop project (see fig 1), along with **new quality evaluation methodologies** to capture cultural, stakeholder and market preferences for a range of traits. He highlighted the especial usefulness of high-throughput phenotyping protocols (HTPP) - mainly spectral analyses to predict sensory and textural traits, and cited the RTB special issue. Professor Patrick Adebola, IITA Yam breeder, highlighted the AfricaYam project outcomes (2014-2020), in terms of i) **capacity** building, including developing its gender community of practice (CoP); ii) building **genomics resources**, including new molecular markers and crop wild relatives (CWR) sequencing; iii) developing a **learning platform**, and iv) building yam (boiled and pounded) **quality indicators.**

2.2 Day 1: AfricaYam partner experiences on quality assessment & PVS

2.2.1 Presentations

The presentations for day 1 can be accessed here.

During the rest of day 1 AfricaYam project partners each shared their experiences in yam quality assessment and participatory varietal selection, followed by specific questions and answer sessions. Presentation outlines are summarized in Table 1, and individual full presentations can be accessed on the RTBfoods Yam Training workshop[3] website pages.

Table 1 Day 1 hyperlinked presentations

Partner[4]	Country	Presentation Title & Content
UAC	Benin	**Yam quality screening and users' acceptability at BIORAVE in Benin**: Yam-quality screening and user acceptability- hedonic (Likert scale): sensory and discriminatory tests- successfully prioritized traits
CSIR-CRI	Ghana	**Yam quality screening & user acceptability at CSIR-CRI, Ghana**: Pest and disease assessments as a starting point for selection
CSIR-SARI	Ghana	**Yam quality screening & user acceptability at CSIR-SARI, Ghana**: PVS-field assessments (tuber characteristics) and food quality assessments made (DM, starch, tuber discoloration, consumer acceptability)
IITA + NRCRI + ESU	Nigeria	**Yam Quality Screening & User Acceptability Assessment at IITA & NARES Partners in Nigeria (NRCRI & EBSU)**: Dynamics of end-user stated trait preferences (via surveys) were explored, allowing needs with breeding objectives to be better aligned …and defined products to better match client profiles; Crosses and breeding schemes progress: visual, data and food quality-based selection integrated into the breeding pipeline process all of which will ultimately lead to greater adoption of improved varieties.
CIRAD	Guadeloupe	**Yam Quality Screening & User Acceptability at CIRAD, France**: PVS-Pre-selection- for some agro-morphological traits evaluated as major achievements: • 2 populations genotyped leading to genetic maps • 34 QTLs identified leading to increased understanding of Yam quality traits • 9 QTLs validated allowing marker-assisted selection (MAS) for developing best Yam hybrids

2.2.2 Q&A

The linked Q&A sessions highlighted concerns in three key areas considering the need for:

A) **Greater consistency of approaches and methodologies**, especially regarding i) Trait prioritization (it is too demanding to evaluate all the traits, so researchers need to agree on which traits can act as proxies for others); ii) which sampling protocols– e.g. panel size should be optimized for both

[3] https://RTBfoods.cirad.fr/resources/training-on-yam-quality-evaluation-africayam-RTBfoods/day-1-monday-22-november
[4] see acronyms list for full partner name- hyperlinks are video-URLs for YouTube presentations

discriminant and sensory panels; iii) which trait selection criteria can be applied; iv) realistic targets for evaluation throughput (how many clones should/ can be evaluated per year (depending on variables etc.), inclusiveness of stakeholders, and ensuring value-chain wide coverage; v) ensuring how to practically process yam in the lab; vi) what trials controls should be established, with how many replicates, in how many locations, and using what fertilization (NPK+) regimes; vii) how long can yam's be stored before dormancy breaks, and at what point should we assess quality after harvest; and viii) what can be fast-tracked to save time.

B) **Consistency of terminology** (e.g. stickiness vs elasticity), where participants expressed a hope that by the end of workshop they might agree, especially regarding confusing terms, aiming for more consensus, and agree on what must be measured.

C) **Consistency of data use for selection.** How can researchers best register and account for the 190 standard ontology data points for yam. These include agronomic, disease and quality traits, but for RTBfoods research focuses on quality only, as they do not have time to gather data on all, although farmers can help gather data and shortlist using triadic comparisons, and with complementary data from processor consultations.

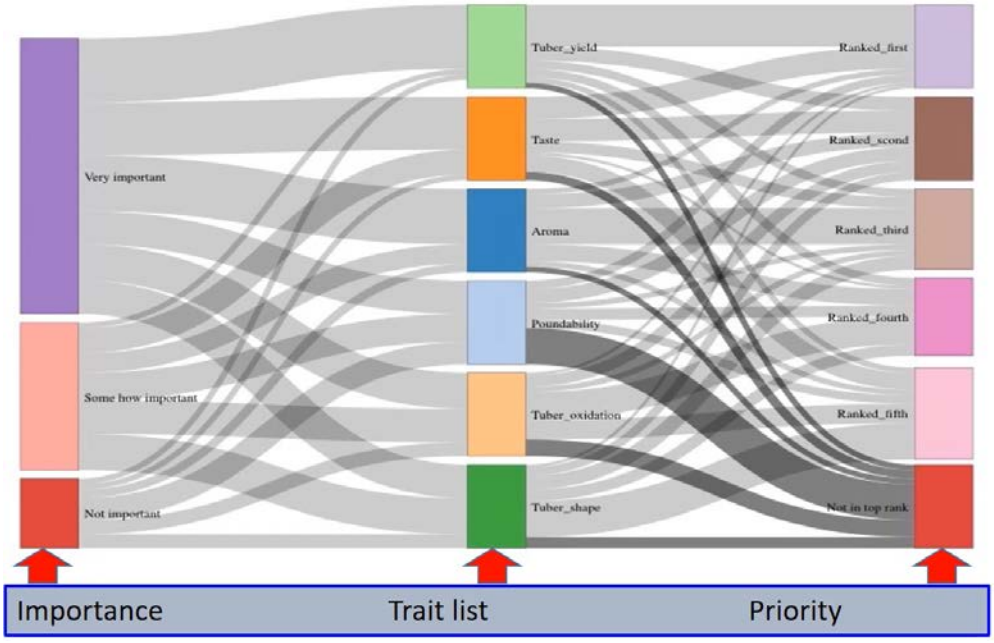


Figure 3 The Dynamics of End-user trait preferences

2.2.3 Panel discussion

After presentations and Q&A sessions, an expert panel[5] was convened to address trainee concerns on yam quality assessment, especially on prioritizing yam quality traits/crosses for breeding programmes. *AfricaYam*'s (AY) experience showed that farmers' and end-users' priorities didn't differ significantly from the AY project's originally-prioritized trait qualities. Key textural selections were done, e.g. for elasticity, but now AY recognizes there is a need to fine tune selection, especially given the greater amounts of seed allowing for a destructive approach early in the breeding process. Panel members also highlighted the need to recognize food quality traits for international markets (e.g. poundability), but at the same time accommodating domestic preferences (including woman-farmers), such as high-yielding, stretchable pounded yam as welcomed in ceremonies, and varieties with improved taste, aroma and yield. Aroma discussions prompted references to incidence of wild yam consumption, and also touched

[5] Panellists: A. Amele, J.Obidiegwu, M. A. Kouakou, A. Dansi, E. Otoo, E. Chamba, H. Chamba, H. Oselebe, H. Chair Moderators: P. Adebola & D. Dufour

on color (yellowness /whiteness), sweetness, uniformity, and shelf-life. The panel considered how sweetness of pounded yam be measured, accommodating different consumer preferences. There were suggestions that taste, and aroma should be considered separately, and a recommendation that sensory panelists' sensorial evaluation skills be updated annually. A panelist highlighted a possibility of also including fried yam as well as boiled and pound yam in quality assessments. In considering regional harmonization, perhaps a parameter list should be drafted to be used across all programmes. The panel agreed that, in sharing best practice, all national RTBfoods partners across 80 locations need a set of common/standardized yam-quality evaluation protocols for an agreed set of key traits, accommodating user preferences. Participants highlighted that taste is the highest priority.

After a closing summary, the originally planned FSA campus tour and lab visit could not take place on account of heavy rain. In the evening, a workshop **welcome cocktail** served to strengthen participants' engagement.

2.3 Day 2: RTBfoods tools for Yam quality evaluation within WPs 1, 2 & 3

2.3.1 Introduction

The presentations for day 2 can be accessed here.

After a reminder of topics covered on Day 1, participants took some moments to honor recently-deceased Cirad scientist Dr Geneviève Fliedel, and her long career in food science with African rural women. The remainder of day 2 presented trainees with tools for yam quality evaluation within RTBfoods work-packages (WPs) 1,2 and 3 (table 2).

Table 2 Day 2 programme

Intro	Wrap-up & remembering Genevieve	
WP1	Synthesis on Pounded Yam Quality characteristics -Bowen Univ., NRCRI, IITA & CNRA- Gender	
	Q&A	
	Panel Discussion	
	Sensory Textural and Chemical analysis	
	Q&A	
	Dean of FSA	
WP2	Sensory Evaluation: Principles & Uses in Breeding programmes	
	Textural Characterization: Principles & Points of Attention	
	Physico-chemical Analyses	
	Q&A	
	Lab. Applications	Boiled Yam at UAC-FSA
		Pounded Yam at Bowen Univ
		Yam at IITA
		Yam at NRCRI
		INRAe presentation on cell walls
	Flip-Boards- presentations of and signup for Day 4 - 5 training sessions	
	Discussion Panel: Translating to MTPs for Implementation in Yam Breeding Pipelines	
	Q&A	
WP3	final comments from Panel	
	NIRS for Quality Traits Prediction: Opportunities & Challenges	
	Overview of Image analysis as phenotyping tool: Yam Quality Traits	
	Possible Applications of Hyperspectral Imaging to Predict Yam Quality Traits	
	Discussion Panel	

2.3.2 RTBfoods WP1: activities for Yam

Presentations

a) Dr **Forsythe**[6] first provided an overview of RTBfoods partners' overall characterization work, relating to user preferences for WP1, and the methodology developed for producing gendered RTB product profiles. Her presentation referred to: i) producing an extract of all traits; ii) developing indicators; iii) identifying 'good' and 'inferior' varieties; iv) developing and applying quantitative diagnostics; and v) ensuring appropriate gender orientation. The gendered product profiles consider the respective RTB raw material; and key characteristics for processing, and for final raw and cooked / ready-to-consume products. Supplementary information on gender and linked livelihoods is also provided; b) Dr **Madu** then presented a synthesis of ongoing work on boiled yam quality, including gendered traits at FSA, NRCRI, IITA and CNRA. The presentation considered four steps linked to the state of knowledge for gendered food mapping, where step 3 provides processing demonstrations. The presentation also highlighted the need for triangulation in effectively assessing raw processed yam quality; c) Finally Dr **Ononiran** presented work from Bowen University, Nigeria contributing to the gendered product profiles accommodating agronomic, processing and final product preferences. The presentation considered essential traits, and traits for niche markets and for added-value.

Q&A and Panel Discussion

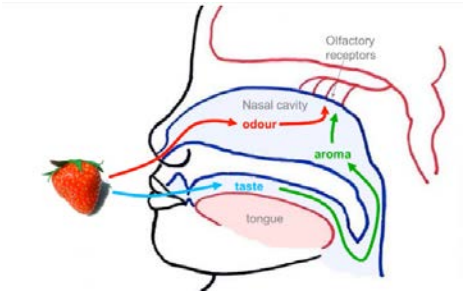
Q&A: Participants reflected which key traits are important to consumers for quality of pounded and boiled yam, and which processing-related traits (rather raw material traits). It was suggested the workshop should focus on diagnostics. For boiled yam these key traits included: *color* (white, creamy, yellow); *ease of peeling*; *taste* (sweetness); and *mealiness*. For pounded yam these included: *smoothness* (no lumps), *texture* (softness); *mouldability*, *stretchability*, and *stickiness*. Here pounded-yam smoothness seems to be more influenced by variety than by processing, although pounding method (traditional vs mechanical) should be accommodated. The Q&A also highlighted a confusion between yam skin hairiness and smoothness, where smoothness equates with ease of peeling needs. There are often trade-offs according to location/country. A question arose on consumers' willingness to pay for superior traits, and relevant market linkages, where yam color and sweetness are most valued, and where awareness building is needed to promote new varieties and their adoption. Breeders' input is essential for robust triangulation

Panel discussion: Relatively few interactions have occurred between WP1 and yam breeders over the last two years, partly as crossing characteristics still need finalizing before sharing with the breeders, and no breeders have approached the team yet. Participants suggested that when and how to include breeders should be the role of PMU. The breeders present in the workshop seemed unanimously delighted at this prospect, and PMU proposed a meeting with them during the workshop. WP1 leadership reminded participants that its work aims at providing data for RTBfoods WP2 rather than for breeders *per se*. The panel discussion highlighted some difficulties encountered during the WP1 surveys, including respondents' differing priorities, mistrust and lack of time, the need to explain some descriptions and interpret exchanges accurately, and inconsistent or ambiguous responses on product characteristics (e.g. ''crying'' yam = moisture content). Participants considered the idea of incentivizing respondents. The surveys were conducted across all stakeholder groups (consumer, marketers, farmer, etc.), and although time consuming generated a wealth of data. The ranking exercise proved challenging in some cases where respondents felt patronized when asked to choose one trait over another. Future surveys should include a breeder be on survey team, as food scientists don't always accommodate agronomic characteristics. Participants agreed that there are some common important traits for both boiled and pounded yam product profiles[7], including texture/mealiness, aroma, color (whiteness) and

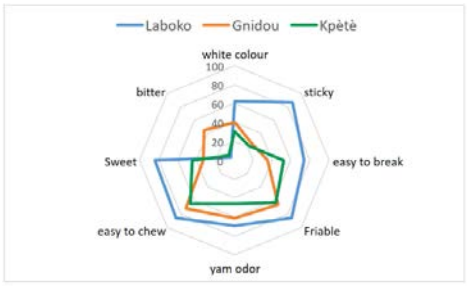
[6] whenever presenters' names are cited, it must be membered that the presentations are the result of RTBfoods partners' teamwork, and all contributors implicitly acknowledged.

[7] the eye eats before the mouth

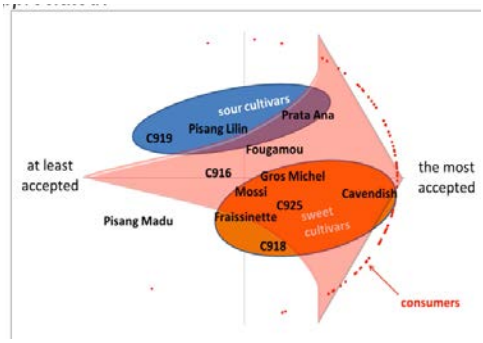
ease of peeling. With the help of champion processors the project has identified two yam clones possessing all these key traits– *Igoo* and *Nwogo*– which are also precocious, and also some cultivars are good for boiling but not pounding, or vice versa, such as *Kamilu* good for pounding but not for boiling. Tuber-size requirements vary according to market segment where long/large yams are sought for ceremonies, and smaller yams easier/ cheaper to transport/export. There are already good varieties found in the markets, and these were used to develop product and breeding profiles, with processors' feedback and using varieties with contrasting traits ('good' and 'poor'). The panel acknowledged a need to further nuance the profiles, considering post-cooking/ processing discoloration/ color changes, and smoothness



A: Aroma, tast and smell



B:Yam sensory profiles



C: Musa cultivar consumer preferences

Figure 4 Some sensory analysis principles

At the end of the panel discussion, the Dean of FSA expressed his heartfelt appreciation of this much-needed RTBfoods yam-quality evaluation training workshop.

2.3.3 RTBfoods WP2: principles for characterization of Yam quality

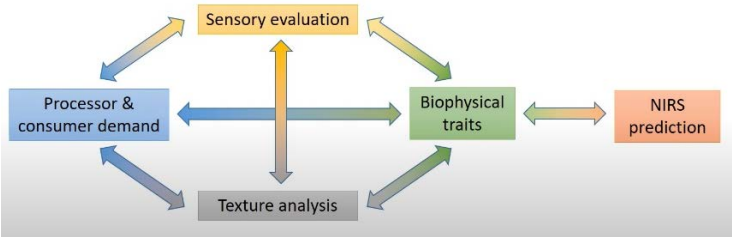
Presentations

Cirad's Drs **Bugaud** and **Forestier-Chiron** presented *Sensory Evaluation: Principles & Uses in Breeding programmes*. Their comprehensive presentation outlined sensory analysis, including the types of tests (descriptive, discriminating, hedonic), and how these are useful for breeding. Participants learned the difference between aroma, taste and smell (fig 4a), the groups of textural characteristics (mechanical, geometrical and physical surface), the importance of triangulation using trained panel judges and the principles of quantitative descriptive analysis (QDA). The 5 steps of QDA are: presenting the descriptive vocabulary, applying the tasting form, using scale, understanding the scale notation, and assessing QDA panel performance. The tests need to be done in a stable environment, using representative samples, and a trained panel, that allows repeatability. Figure 4b depicts QDA sensory profiles of three boiled yam cultivars. Along with principle component analysis and high-throughput phenotyping, QDA is useful for breeders, processors and consumers. Figure 4c depicts sensory analysis of consumer preferences for sweet and sour banana cultivars

Drs **Dahdouh** and **Ricci**'s presentation on *Textural Characterization: Principles & Points of Attention for textural profiling*, described texture, texture analyses (TA), some instrumental tests, and the key steps to validate a texture test (standardize, investigate, evaluate, correlate, and analyse). They provided insights into how breeders can use TA, and stressed that TA needs time for validation; willing

collaboration; and fluent statistical knowledge. Workshop trainees would be given the opportunity to see and in some cases to practice these tests and look at data analyses on days 4 and 5.

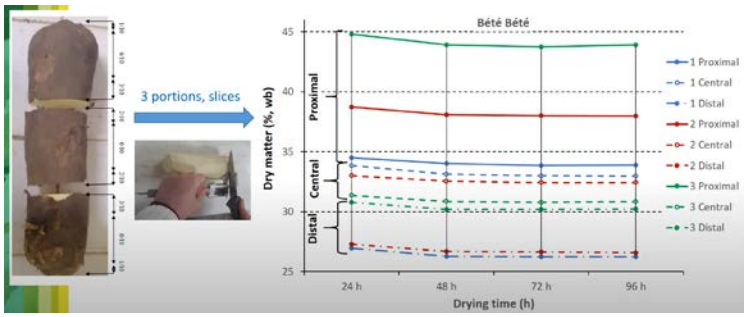
Dr **Mestres'** presentation outlined physico-chemical analyses for yam quality (see fig 5 for examples). Once the candidate cultivar has been identified, using representative samples, analysts can establish and then validate the standard operating procedure (SOP) for traits (e.g. dry matter or pectin content) determination. He presented assessments using the case study of water and pectin content linked to texture/quality including information on near infra-red spectrometry (NIRS) calibration and hyperspectral imaging (HSI).



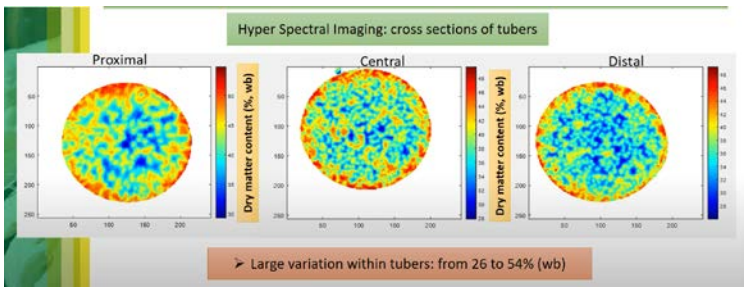
A: yam quality analysis context

Characters	Characteristics	Expected Lab analyses
Colour	White or yellowish	*Lab colour, total Phenols*
	Dark / brown / purple (poor)	
Texture in hand	Sticky to the fingers	*TPA? Starch ? Amylose? Pectin ?*
	Hard to break (poor)	*Penetration test*
Texture in mouth	Easy to chew	*Penetration test, TPA, Water content ? Starch ? Amylose? Pectin ? Cell walls, fibers, swelling power*
	Ater	
Odour	Boiled yam odour	*GC/MS*
Taste and aftertaste	Sweet taste	*Sugars (glucose, fructose, sucrose)*
	Bitter taste (poor)	*Total Phenols, Glycoalcaloïdes*
	Bitter aftertaste (poor)	
	Tasteless (poor)	*Sugars, Polyphenols*

B: Selecting the appropriate lab analytical tools



C: variability of DM content between Yam cultivars and within individual tuber



D: HSI of proximal, central and distal tuber parts

Figure 5 Aspects of physico-chemical analyses

Q&A and Panel Discussion

Panel interaction: Participants were reminded that all validated protocols are on posted on the yam-resources page of RTBfoods website

Q&A on NIRS, Hyperspectral, Imaging

i) The panel confirmed that a single experiment could *quantify multiple textural parameters*, and this would be demonstrated on day 4, including which traits may be evaluated together.

ii) When measuring dry matter, blending is not always necessary before measurement, although *blended samples* have given more reproducible results with higher statistical accuracy.

iii) Trainees asked how to *maintain consistent temperatures* during texture measurements especially when analyzing many samples at once. One approach for boiled yam is to stagger testing in 10-minute batches, or set all samples at elevated temps (e.g. in water butts at 50C). Temperatures should be recorded during and after cooking, and analysts consider delaying test for a standard amount of time. IITA uses controlled-temperature boxes allowing performing all tests at the same temperature. Sample temperatures can be maintained in Styrofoam sample boxes, by keeping samples together in temperature control equipment, and by ensuring short distances between preparation and measurement. A practical approach will facilitate logistics, that are critical for ensuring consistency in SOP implementation, especially where labs have limited

facilities for controlling the conditions. There is no fixed cooking protocol for managing different varieties' cooking kinetics, and so more work is needed on establishing optimal cooking times. **iv)** To better manage the wide variation in product consistency from sample preparation to measurement, evaluators need to understand the product and also calibrate their sensory analyses, as each yam variety has different properties. **v)** In giving breeders analyses results, food scientists have focused mainly on the *medial* parts of the tubers (this shows best after longitudinal analyses), but analysts should include results from all tuber sections as most consumers do not discriminate, and this could affect acceptance. **vi)** Participants expressed doubt on how best to validate their textural analysis especially when sensory analysis is to be correlated with textural analysis (e.g. starch content). **vii)** In establishing thresholds after textural measurements for quality traits for different genotypes, analysts should conduct consumer and discriminatory tests that assess a wide range of cultivars. After establishing all WP2 QDA results, analysts should liaise with breeders to establish 'good', 'medium' and 'poor varieties' then conduct textural measurements to determine threshold ranges for calibration.

2.3.4 RTBfoods WP2: Lab applications for Yam quality analysis

Presentations

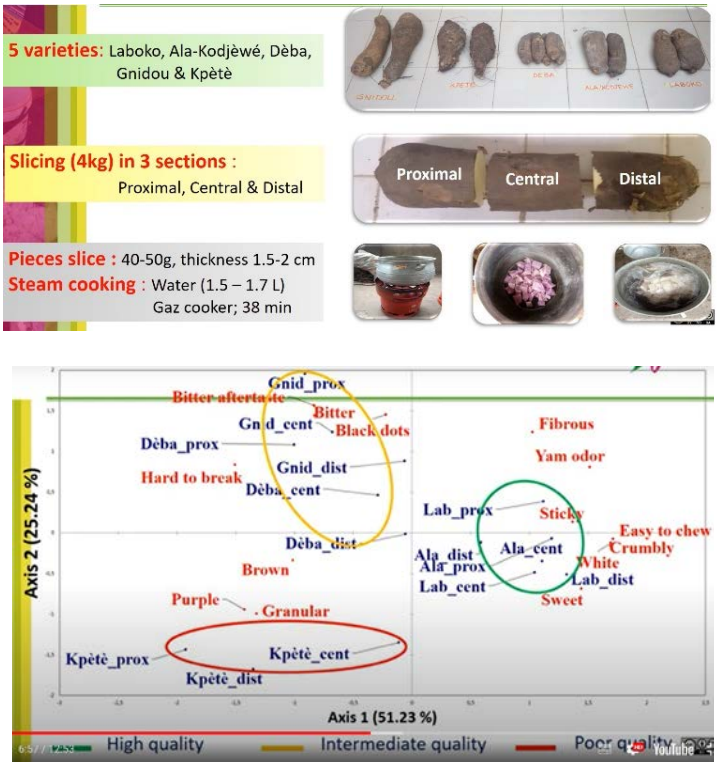


Figure 6 Further aspects of yam tuber quality analysis

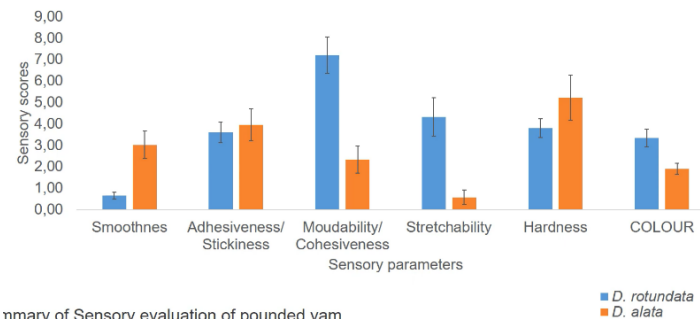


Figure 7 Yam sensory parameters- 2 cultivar comparison

Six RTBfoods partners (UAC-FSA; Bowen University; IITA, NRCRI, INRAe, and Cirad Guadeloupe) presented their work on lab applications for yam quality analysis as follows:

i) Dr **Adinsi** of *UAC-FSA* presented principles of boiled-yam quality analysis, including sampling, preparation, cooking, sensory profiling, and biophysical characteristics (drying/ lab analyses). Their presentation included gender food-mapping, with examples of four highly-preferred cultivars, and sensory mapping for traits such as DM etc. There was some discussion about when to use the penalty (destructive?) test for the other products where PCA is effective in discriminating. adequately.

ii) Dr **Otegbayo** delivered a presentation on pounded yam lab analysis at *Bowen University*, including translating user-preferred traits within the yam product profiles. Comparative work was based on 6 *Dioscorea rotunda* (browner) cultivars, 6 *D. alata* cultivars, and one farmers' cultivar. It articulated analytical methodology, including how to work with sensorial panelists (criteria, selection, approach etc.), through to final evaluation. References to starch granule morphology, pasting properties of raw yam, and texturometer seemed useful. Dr Otegbayo concluded that 'instrumental color' could be a useful HTPP method for color; and both yam pasting properties and instrumental texture

profile analysis (IMTPA) could be useful for medium throughput protocols (MTP).

iii) Dr **Adesokan**'s presentation on *IITA*'s work developing the SOP for yam quality evaluation, highlighted 16 identified pipeline genotypes for best cooking times and water adsorption

(also demonstrated using a compression probe). After training 14 panelists, the team correlated chewiness and water adsorption, along with hardness. He concluded that i) there was a significant positive correlation between instrumental and sensory hardness, ii) although chewiness correlates well with water absorption, the method presents difficulties, and iii) cohesiveness links to mouldability.

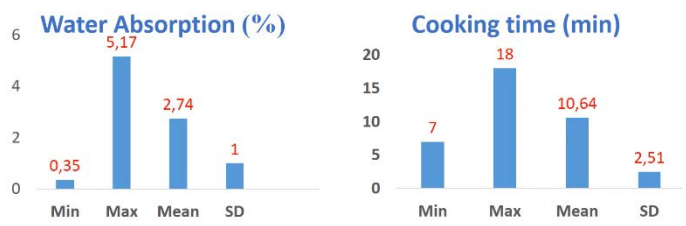


Figure 8 Water adsorption and cooking time in boiled yam

iv) Dr **Chijioke**'s presentation covered *NRCRI* Nigeria's fresh, boiled and pounded yam evaluation work for several post-harvest traits, including chemical, pasting, functional properties; and cooking/pounding time. A combination of eleven *D. alata* and *rotunda* genotypes were evaluated from two locations, after three months storage time, using three tubers per genotype, that were sectioned for penetrometry, cooking time, dry matter and amylopectin content etc. Another experiment used 13 cultivars from 2 locations. She highlighted a need to explore relationships between sweetness and cooking time, to develop and calibrate models to measure other yam quality traits, and especially to look more closely at yam's biophysical properties. She also confirmed that NIRS can be used as an HTPP method for DM analysis.

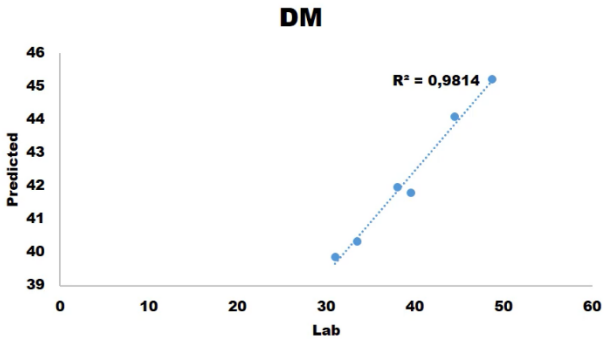


Figure 9 Predicted and lab-measured DM correlation

v) Dr **Dutheil** delivered a presentation on *INRAe*'s yam cell-wall studies, considering the impact of non-starch polysaccharides (NSPs) on the textural behavior of processed yam. She explained that starch, DM and amylose don't fully explain yam textural properties. Yams are rich in NSPs (cellulose, hemicellulose, pectin and mucilage), including monosaccharide galactose, a key sugar, especially *D. esculenta*. The chemical signature of yam NSPs can significantly influence cooking properties. INRAe studies examined pectin behavior linked to two enzymes (PME and PG) that helped map out yam non-starch NSPs, after starch removal, in five cultivars representing both *D. alata* and *rotunda*. Cooking decreases methylation and hydrolysis of NSPs in one species but increases levels of NSPs in the other. The work aims at elucidating mechanisms of pectin modification in cooking, also highlighting that soil chemistry can also affect cooking behavior. **NSP methylation** levels can be measured by NIRS, which could provide a useful means of characterizing yam cooking behavior.

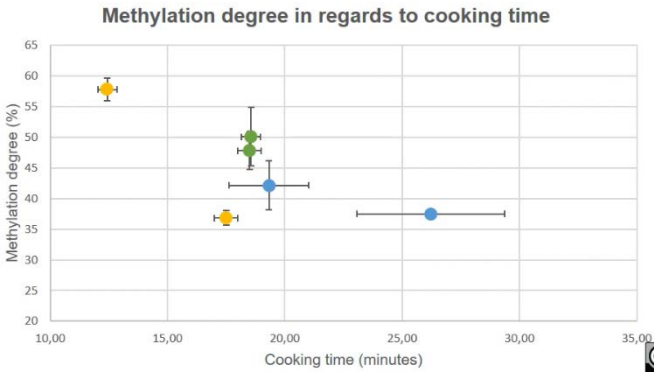


Figure 10 Methylation and cooking time correlations

vi) A French presentation on amylose measurement from *INRAe Guadeloupe*, by Dr **Desfontaines** was not screened during the anglophone workshop, but remains available on the RTBfoods website.

WP2 Discussion Panel: How to Translate into Medium-throughput Protocols for Implementation in Yam Breeding Pipelines?

As with most characterization processes, for yam, there are too many traits to evaluate comprehensively. Moderating the discussion, Dr **Otoo** of *CSIR-CRI*, Ghana reminded participants that this subject had already been discussed in a pre-workshop meeting and traits-profiling discussion by breeders. For boiled yam, from 40 traits the group had identified to 8 key traits, and for raw yam, discussion centered around moisture content, color and texture, but a follow-up meeting is needed to translate their considerations. This WP2 discussion revealed that, as well as from the WP1 data, protocols development had also been informed by a consultation with farmers, processors, and consumers regarding their trait preferences, although there needed to be more **interactions with breeders and social scientists**. Cooking time, discoloration, and drivers for using certain cultivars were also discussed. However, evaluation can be slow and costly, hence a need to **prioritize different sectors of users**, and especially to generate more breeders' buy-in. The discussion also considered newly observed differences, where participants agreed that water absorption, cooking time, and cooking and textural qualities need to be prioritized, including by breeders. Further **harmonizing the SOPs** will allow replicability and add more value than just sensorial understanding, and this should be done before sharing with breeders. However, analysts will need to represent the whole range of sensory traits with **key proxies** and complement sensory panels with a poly-instrumental approach, for example to evaluate texture a single SOP should be able to discriminate between all cultivars, using robust criteria. A **new platform** could stimulate greater interactions between WP1, WP2 and breeders, as well as providing greater access to protocols by breeders. Evaluation practices such as lab **protocols need to be user-friendly** for breeders and other field users, so **portable equipment** should be made available (e.g. Colorimeters, hand-held NIRS, thermometers, etc.), and the more easily measurable traits given priority.

2.3.5 RTBfoods WP3: High-throughput prediction of quality traits

Presentation

i) Drs **Davrieux** and **Alamu** delivered a presentation on *NIRS for Quality Traits Prediction: Opportunities & Challenges in Practice,* first introducing the principle of NIRS, based on quantum theory, selective light adsorption and a spectral database. It provides a non-destructive, speed-of-light tool for qualitative or quantitative evaluation of raw or processed products, needing database management competence and a well-equipped law. The presentation considered DM and starch in fresh & blended yam, covering sample preparation (blending, chopping, grating) and measurement. They considered the opportunities for and challenges to this approach, including that minimal sampling is required, the analysis time is short, there are no hazards, and the method is cost-effective and accurate, and has few steps. However, a skilled operator is needed, and it can be difficult to accurately predict some quality traits of end products (especially where chemical reactions occur in sample preparation)

Due to lack of time, the two others scheduled WP3 on ii) *Opportunities for **Imaging** as a phenotyping tool*, and iii) *Possible Applications of **Hyperspectral Imaging** to Predict Yam Quality Traits* were deferred until day 4.

WP3 Discussion Panel Exchanges

When asked if we might expect reliable measurement of yam texture from NIRS and Hyperspectral Imaging, the panel responded that i) some traits have been successfully measured such as dry matter; ii) measurements for texture evaluation in boiled yam and gari need improvement, and not all textural qualities can be evaluated in this way; iii) this technology allows for discriminating between 'good' and 'poor' yam varieties; iv) it may be possible to evaluate yam biophysical characteristics using these methods; v) there are some direct correlations for yam traits, but classifications of foodstuffs by phenotype linked to genotype need developing. Analysts are considering indirect approaches but need

to see if there are some correlations, and develop equations e.g. for cooking time. Evaluation work on sweetpotato and cassava mealiness is already well-advanced, which could help develop the approach also for Yam. There were some unexpectedly low-scoring NIRS results for unblended samples, for which, the panel explained, the coefficient of determination needs additional criteria such as standard error of prediction (SEP). If the R^2 is fair, but SEP is also low, this indicates a need to improve on the model. Also, prediction of wet samples is often less accurate than for dry samples. Minimum required sample numbers are specified in the SOP (100 genotypes minimum for evaluation, validation: 20 genotypes), however the variability among the samples obtained from a larger number of variants is very important, rather than the number of the samples. As new variants are developed, the dataset will need extending to account for this variability during measurements.

Day 2 Concluding Session

The panel concluded that: i) this workshop has for the first time provided **breeders and food scientists the opportunity to come together**, and this will surely bear fruit through improved hybrids that better serve users' needs; ii) Breeders, and food and social scientists must together to **rank and streamline key traits** for easy adoption; iii) Although understanding sensorial analysis is the main journey, the challenging destination is to **correlate sensory and biophysical traits and then approach breeders**; and iv) results from **newly-emerging sensorial analysis** will also need to be integrated.

2.4 Day 3: Ganvié, lakeside village

The photos and videos for day 3 can be accessed here.

Pascale Lajous (Text & pictures)

After the first two days spent in plenary sessions and a dense program based on theoretical presentations, day 3 offered a welcome break as an informative and peaceful trip for trainees, providing an opportunity to relax and build group cohesion.

From the pier in Abomey-Calavi, participants split into small groups and boarded traditional Ganvié fishing boats. On board each boat, guides explained Ganvié's lake-city life, essentially based around fishing, and an extraordinary life on the water. Boats visited their fish-farming plots that attract fish with the help of dead branches.

As participants arrived at the quay in the town of Ganvié, which is mostly built on stilts, local dancers and musicians provided an animated welcome, generating a charming atmosphere, and offering a total change of scenery. We shared a lunch so we could taste some of the

main Beninese yam varieties (boiled, pounded, Wassa Wassa, amala/elubo). Afterwards participants attended a voodoo dance show presenting traditional costumes and music, and images that remain fixed in our memories.

Back on the mainland at sunset, a light wind had risen, blowing towards the lagoon, and in the sails of the boats brought back by the fishermen's wives who were returning after their day of market. This interlude in the middle of the training week notably favored a rapprochement between trainers and trainees, and as a prelude to the workshops on yam sample preparation, sensory analysis, and measurement of texture and color by image analysis.

2.5 Day 4: practical training in characterization of Yam quality- sampling, preparation, sensory & textural analyses

2.5.1 Introduction

Trainees were first provided with summary of what had been covered in day 2. Also, during day 2, trainers for the scheduled practical sessions had provided a 3-minute snapshot of the four training sessions. Then trainees had been invited to sign up for the quartet of rotating practical training sessions for days 4 and 5. Each session was scheduled to run 3-4 times for around 8-10 trainees per session, to allow sufficient hands-on opportunities for all trainees.

The four parallel sessions offered were:

1. Sensory training- look at main descriptors for boiled yam, the scale, how to be part of a training / tasting panel,
2. Textural training, talking about rheology and boiled yam, and the SOP for evaluation
3. Context and use of NIRS spectra for calibration
4. Quality traits analysis- focus on hyper spectral imaging

Figure 11 Signing up for practical sessions

2.5.2 Presentation

To prepare trainees for the practical training sessions, Drs **Bugaud** and **Forestier-Chiron** provided an exemplary presentation on *SOPs for Characterizing Yam Quality: Sampling, Preparation, Sensory & Textural Analyses*, emphasizing that this is not a hedonic testing approach.

Quality descriptive analyses (QDA) are used to differentiate between products, that allow concise and precise product descriptions using descriptors for describing appearance such as type; attribute; and definition (of attribute). The protocols articulate how to measure (0-10 scale) for aspects such as color and texture. After defining the number of samples, their texture is evaluated by feel in both the hand (stickiness, hardness, crumbliness), and in the mouth (granularity, chewiness). Taste is then evaluated on the tongue (for sweetness and bitterness).

The panel members are comprehensively trained in advance of evaluations, starting with around 15 -20 candidate members, resulting in 8-12 who fulfill panel criteria in terms of their availability, reliability, punctuality, and willingness. There are no restrictions for gender or age, and a panel member can be considered like a machine. Panelists need to know how to use the scales, and cumulative experience is critical.

2.5.3 Practical exercises

Practical Exercise 1: Sampling & Sample Preparation for Steaming of Yam Tubers for Lab analyses

Trainers first reminded trainees of the important principles and outlined the steps for sample preparation. Each group of trainees then participated in:

i) Dividing candidate yam into three section (distal medial and proximal);
ii) Cutting off ends of each section
iii) Transversely cutting each section into discs
iv) Peeling each disc
v) Washing discs
vi) Punching as many sample cubes as feasible according to the sample size
vii) Steaming the cubed samples for 38 mins

Set of practical exercises 2 on boiled yam:

a) <u>Textural measurements (TAXT2) (extrusion & compression tests)</u>

Using samples prepared in Exercise 1, trainees were able to see how sample texture was evaluated using the equipment described below:

i) Conducting textural measurements on the cubes using a **texturometer** to measure the stress/force required to penetrate yam sample
ii) Using a **rheometer** (measures force/ oscillation and rotation to measure viscosity/ elasticity (strain) or speed of penetration- more used for liquids/ semi-solids)

These methods allow repeatability, and timed textural analyses, and can be used to discriminate between 'superior' and 'inferior' cultivars, and also can examine re-structuration.

Figure 12 Sample preparation for boiled yam sensory analysis

b) Sensory analysis (QDA protocol)

Trainers reminded trainees of the criteria for selecting panelists for sensorial analysis (see 2.52) and introduced them to a typical set of QDA descriptors (see example in Table 3), which tabulates the four *types* for evaluation for yam quality: i) **color** of boiled yam sample, ii) **texture** by feel **in the hand** (stickiness, hardness, crumbliness), iii) **texture in the mouth** (granularity, chewiness); and **taste** on the tongue (sweetness and bitterness). For each of these four *types*, the descriptor table provides *attributes* (column 2), the *definition* of the attribute (column 3), how the attribute is *measured* (column 4), and the *scale* or level of attribute (from 0 being absence of attribute, and 10 being complete presence of attribute- column 5)

Table 3 Example of QDA descriptors

Type	Attribute	Definition	How to measure	Scale
Color	White color	Both inner and outer color can range from light-yellowish (off-white) to white (pure white)	Observe the surface of product and evaluate the intensity of each type of the color and its homogeneity	0 = off-white 10 = pure white
	Purple color	A purple color drawing on the pink		0 = no purple 10 = purple

trainees were then provided with three different cultivar sample cubes of boiled yam, with some contrasting and some similar types for color, texture and taste, and provide their individual assessments according to the descriptors definitions and scales. Evaluators are also required to sign a consent form (ethical clearance). The data from all 30 trainee assessments were analyzed, and presented on day 5. A small minority of trainees provided acceptable QDA, emphasizing the need for sensorial training, and an inherent capacity for sensorial analysis.

c) NIRS Spectra Manipulation

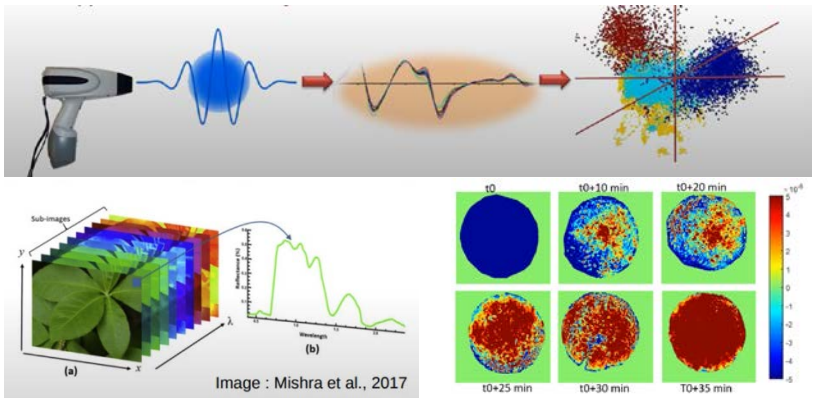


Figure 13 Spectral imaging

Dr **Meghar** gave a presentation on *Possible Applications of Hyperspectral Imaging to Predict Yam Quality Traits*, focusing on developing the proof-of concept. The technology allows for spatial visualization of different biochemical constituents of any sample, which is not possible with conventional spectroscopy (e.g. NIRS). Trainees were reminded of how to use NIRS as a critically important tool for analyzing yam quality traits, and of the power of multivariate data analysis employed in these types of evaluations. The trainer also provided some useful technical tips regarding NIRS open access software (e.g. CHEMFLOW[8])

d) Image Acquisition and Analysis for Phenotyping

[8] https://www.chemproject.org/Home/News/2020-10-15-Training-CheMoocs-ChemFlow

Dr **Cornet** gave an exemplary presentation on *Opportunities of imaging as a phenotyping tool* including sections on image acquisition; sample pre-treatment; image interpretation; numerical images, and size and scale (color). Benefitting from 20 years of the Cirad trainer's image-acquisition and analytical experience, trainees learned some practical and useful tips on how to produce meaningful, analyzable images. These included: i) opting for visible imagery (as opposed to invisible spectra), and using a reasonable quality digital camera is normally the best and cheapest option; ii) follow the basic principle that good image data will provide good results, so ensure points iii) to vi) are observed; iii) ensure color measure quality, in terms of stability and accuracy; iv) always use appropriate materials in terms of the location/ room/ studio; lighting, and equipment (camera, tables, ceramic knife), and set these up in advance of image capture; v) ensure the camera can be adjusted to the minimum required settings (image and pixel size); vi) image quality check using a color reference chart, which depicts the complete range of colors which will be encountered during the image analyses, and that will ensure color accuracy and stability, with consistent color characterization.

Day 4 Participants' feedback

Trainees, food-scientist trainers and attending yam breeders were all given the opportunity to provide feedback in the last session of the day.

Trainees, and in particular the junior trainees, expressed their general appreciation of the textural and sensory analysis training, and participatory tasting, which allowed them to see those areas where quality evaluation errors might so easily be made. They were pleased with the hands-on experiences gained in the sample preparation and textural panel exercises, and the interactive nature of the sessions which raised many issues, and explained very well the concepts behind the protocols and equipment. Trainees also agreed that the workshop was too short, even though it provide an encouraging opportunity to establish useful correlations with sensory data, some trainees demonstrated high-level skills for participatory sensory evaluation. Many trainees were witnessing the imaging technology for the first time.

Trainers observed the dynamic group interactions, with many questions, and language barriers largely overcome despite the diverse backgrounds of the trainees, and the heat. However, some participants appeared more interested than others. Trainers also acknowledged once again FSA for moving things forwards, A trainer noted significant differences between the three groups of trainees and individuals for the sensory evaluation exercise, and another trainer stressed the importance of remaining objective throughout the process. The training aimed to transmit the importance of methodology in evaluation, of being healthily skeptical of the literature, and rigorously controlling evaluation methods. In finishing their debriefing, one trainer rhetorically posed the question, 'were we tasting the flavor for the future?'

Breeders provided enthusiastic feedback regarding their impressions and how they propose to interact with food scientists in the future. They were heartened to learn how food scientists can eliminate bias, and how all stakeholders can better understand and evaluate characters like color and texture. Breeders also expressed excitement at the new prospect of applying the learning in their breeding programmes, and how to develop and better use the tools demonstrated in the workshop. They also expressed the intention of applying the new learning and workshop approaches to more effectively solving the problems of adoption and acceptability faced by the breeding programmes. The breeders' panel expressed its overall appreciation to the workshop facilitators and organizers, the RTBfoods team, and the Cirad PMU in particular.

PMU. On behalf of the organizers, Dr Dufour stressed that despite challenging workshop logistics he complimented the participants on their punctuality and engagement levels, which had made the workshop such as success. Dr Dufour invited the trainees to offer a single last comment on the day, to which a junior scientist responded, "*I am very grateful that 'someone like me' has been given this great* [professional development] *opportunity*."

In the evening, workshop participants enjoyed a splendid dinner at Benin beach restaurant, *La Cabane du pêcheur*

2.6 Day 5: characterization training (continued); data management, and panel discussion on breeding more effectively for yam quality

2.6.1 Practical exercises 3 and 4, plus presentations

The presentations for day 5 can be accessed here.

A summary of day-4 activities was first presented to reinforce the learning, followed by presentations, practical exercises and discussion:

Presentations/ exercises

i) Drs **Bugaud** and **Forestier-Chiron** gave a presentation summarizing the outcomes from day 4 textural and sensory analysis training, regarding the statistical analysis of data collected from 3 groups, demonstrating the wide variability of novice evaluators' assessments of the three different yam cultivars. The session reinforced the importance of panel member selection criteria in terms of particular evaluation skills. It is challenging to present statistical methods to such a heterogenous group, where presenters demonstrated some tools to treat the data and provided advice for interpretation. A useful MS Excel statistical analysis facility is available as XLStat. Yesterday's data was presented using boxplots, radar plots, Anova, principal component analysis (PCA), multilinear regression and RMSE, that help predict any relationships between sensory attributes and biophysical parameters. These approaches are also articulated in the three WP2 reports on: i) training a sensorial panel[9]; ii) monitoring panel performance/ cleaning panel data for statistical analysis part 2 2021[10], and iii) statistical analysis (on PCA/ multiple regression) to visualize sensory analysis data (to be discussed in this session[11]).

Panel training takes time, and repeat trainings are needed to ensure consistency. A radar plot of yesterday's data clearly showed differences between a trained panel and an amateur panel. Pre- and post-training plots (for up to 10 sessions) demonstrate when required competence levels have been achieved in terms of repeatability and discrimination.

PCA can help visualize interactions between any two variables in 2d or 3d, for example some yam cultivars display variation between digital, proximal and central tuber portions and overlaying plots can allow seeing different elements. Or we can examine the relationship between energy and hardness or bitterness for example.

Linear regression is a commonly-used statistical tool for which analysts need to find extreme clones to establish ranges to calibrate for regression (and validate using another dataset)[12] . rely Linear regression can help assess texture (need at least 20 data points). For validation, analysts are advised to repeat panel tests. With good predictions a model can be used for up to 10 years for helping to assess quality

After the presentation, there was considerable debate regarding a range of RTBfoods project issues, related to yam quality evaluation.

ii) Drs **Bugaud** and **Forestier-Chiron** gave a follow-up presentation on *Relationships between sensory data and textural parameters*, and how to correlate consumer testing with sensory evaluation for defining *acceptability thresholds* for sensory traits (in WP1 and WP2). Presenters considered how to integrate consumer preferences into breeding programmes via interactions between consumer testing and

[9] see RTBfoods platform (2018)
[10] see rules on repeatability
[11] see also Elsevier Sensory texture Plantains paper (2020)
[12] see webinar of Antonin Kouassi

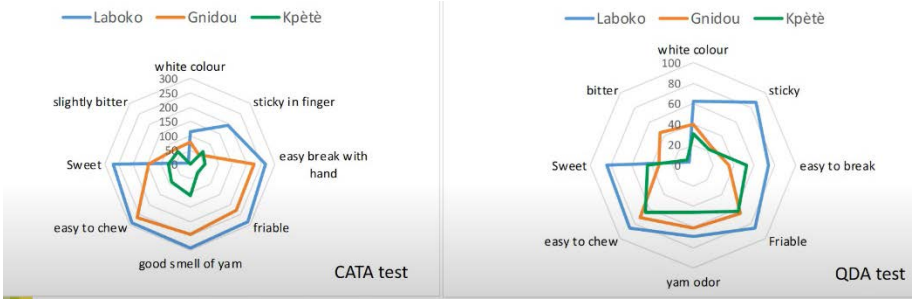


Figure 14 The comparability of CATA and QDA tests in sensory analysis profiling

sensory evaluation. They explained how to identify acceptability thresholds, how to apply hedonic and sensory profiles, and how to overcome limitations and constraints. They referred to a range of analysis approaches including 'just about right' (JAR) testing, quality descriptive analysis (QDA), and 'check all that apply' (CATA) testing, that together could validate the acceptability thresholds. A range of 4-7 cultivars are needed over different trials locations to accommodate variability. The presentation concluded that acceptability thresholds are being established and validated within WP5, although some thresholds are difficult to identify.

iii) Dr Ngoh-Newilah gave a presentation on *Methodology for participatory evaluation (PVS) of new yam hybrids* (WP5 linked to other WPs), which explored how PVS can contribute to breeding pipelines, using different tools in-field and in-lab to assess raw material, processability and final product quality via product champions. He considered WP5's gender-equitable positioning and relevance to crop selection for new clones, stressing the need to validate processability and final product quality assessments, and develop a harmonized evaluation methodology (adaptable to contexts) for most promising, user-preferred traits. The September 2021 guidelines are under currently review. The presentation included the following topics: i) main **traits selected** in previous WP1work; ii) **Trials** composition (including one 'poor' and selected local 'best' landraces, and with plots that would be large enough to supply material for evaluation, established according to standard trials protocols; then traits for iii) **Agronomic Evaluation**; iv) **raw material evaluation** (including measure to ensure stabilization, adequate quantity supplies and effective logistics); v) **processed material evaluation** (number of clones; processing techniques; evaluations with users (rural-urban); (compensated champion processors (using obtained products); processing arrangements (pre-harvest), monitoring times; and vi) **Consumer testing** (design depends on clone numbers; product preparation; consumer-testing sampling- 100 consumers per location.

The presenter also highlighted missing traits of flour yield, and processing times and quantities. In his final comments, he articulated the way forwards, and mentioned the WP5 workshop on triangulation of comparison of technologies (TRICOT) method. He emphasized that partners need the list of SOPs and selection criteria lists. Difficulties for TRICO included pandemic mobility constraints, delays due to holidays, and unresponsiveness.

The workshop timetable had scheduled the continuation of rotating, parallel training sessions on yam tuber sampling and sample preparation for lab analyses (including NIRS), and on boiled yam textural measurements and sensory analysis. However, a power cut meant certain elements planned for the final day could not be accomplished as planned, although most of the parallel training sessions were able to continue.

Other presentations on yam ontology and database scheduled for day 5 could not be projected due to the extended power cut, but these can be viewed on the RTBfoods website as follows:

iv) **Dr Asiimwe**'s Presentation: *Ontologies for yam food quality traits*

v) **Dr Afolabe**'s Presentation: *Storing yam quality data in yambase*

2.6.2 Q&A

In panel responses to several questions on consumer-testing and PVS, the following information emerged:

- Twenty minutes' yam cooking time is sufficient for evaluations, using standard cubed samples as demonstrated.
- Evidence of multiple synergies between WP1 and WP5 has emerged.
- The number of trial replicates depends on the size of trials– less in larger fields, but normally 2-3 replications after which the roots can be bulked. Three processors with 3 replications according to the SOPs would be sufficient, and results from WP5 research helps build external validity of lab evaluations (eliminating drudgery and processing time). So only for advanced clones are three processors per location necessary.
- To avoid inconsistences the time limit between harvest and lab-processing should be minimized (e.g. to avoid moisture loss). Efforts to establish a mobile lab facility are ongoing, but it can be difficult to accommodate bulking. A simple solution is to send root samples immediately to the lab.
- Guidance is needed regarding the minimum number of participants in consumer testing, as 100 seems a lot to manage, especially where many locations are involved (Nigeria has 12 locations). It could be possible to accommodate variability with smaller samples from promising clones only. It is challenging to evaluate more than five clones at a time.
- When participants suggested that SOPs should include data analysis guidance (or at least integrate WP1 and WP5 for this), they were reminded of WP1 guidelines concerning processing and consumer testing.
- There was some discussion regarding misunderstanding about the term 'consumer testing'- which includes farmers' evaluating material, and formal consumer testing. A more rigorous testing scope should accommodate rural and urban, gender, region and so forth– IITA, for example normally interacts with local communities. Food scientists and breeders must decide whether or not breeders work includes consumer testing.
- In highlighting the need for new tools for breeders when testing these materials at point of varietal release to facilitate/ promote adoption breeders, we must accommodate cultural considerations and meet policy requirements.

2.6.3 Breeding more effectively for yam quality: panel discussion

In opening a yam breeders panel discussion on *How to integrate end-user preferences and more effective evaluation into yam breeding pipelines*, the moderator acknowledged the wealth of learning provided by the workshop. She posited that 'food scientists need tools and breeders need traits, but these traits need prioritizing and correlating to maximize adoption'. Such work could also be supported by cooking demonstrations. The panel of breeders was then invited to provide their perspectives on three main questions, and although the responses did not always directly answer the questions, the answers generally provided the forum with indications of next steps and votes of confidence:

Q1 Through what you saw this week, what is missing for your own programme, and what is not relevant?

- Some yam-breeding programmes lack adequate human resources for trials, part of which could be compensated through increased mechanization.
- Quality traits of many varieties must inform selection; Some breeders' methodologies need standardizing, and Strengthening links between breeders and food scientists will add value but will also take time.
- The textural profiling, tools and approaches to assess candidate material are very useful. For new candidate material, the workshop learning will provide rapid and easy screening techniques via high throughput protocols to evaluate quality traits, especially those that are complex and thus demand more from screening tools.

- Breeding is a game of numbers in which breeders have to select the best from the many – the sensory evaluation tools will help fast-track the hitherto cumbersome and lengthy breeding process. Contact has already been made with potential collaborators for sensory evaluation. The excellent project progress and training will enhance cultivar improvement.
- The workshop interactions have helped better understand the WP1 issue of harmonizing nomenclature to capture differences, and WP5 methodology on PVS is already doing this to some extent. Colleagues are networking to achieve these outcomes. RTBfoods predictive tools will boost adoption. The significant issue that 'food cannot be elastic' captured one breeder's attention, who is looking forwards to accessing the appropriate protocols and harmonizing these with colleagues.

Q2 What one thing will you implement in your programme as soon as you reach home.

- Despite scant government resources we need to employ food scientists to help with screening as a team, so perhaps we can access other resources such universities to achieve this. Although it should be easy to download all the SOPs and to apply them, lack of human resources will continue to constrain the breeding programme, unless we invest in human resources
- The fast-approaching yam harvest will provide a timely opportunity to use PVS learning to assess cultivars vegetative traits and harvest rates
- Breeding is incremental and linear, and in assessing agronomic traits, breeders we must also consult with food scientists to build multi-disciplinary teams to implement best practice in the best labs in West Africa
- The workshop learning will inform a new food science approach of sampling and sample preparation for textual analysis to improve current approaches
- The strong RTBfoods team provides the means to see and reflect on how to improve yam breeding, considering personal assumptions and which tools can be used in a modest lab context. There is perhaps a need to develop a collaborative breeding strategy. The perception that breeders must do everything in isolation shifted with the realization that these tools can be applied to improve the work.

Q 3: How do we plan to integrate these tools and how can we rank these tools

- Breeding needs multidisciplinary teams and roles, all requiring a vehicle by which we need to understand what our product and what blueprint or map can will specify what we can deliver with such teams. For example, in boiled yam where chewing quality or hardness are key traits, all the team needs to be involved: breeders agronomists pathologists food scientists and social scientists. We are now waiting for RTBfoods to deliver these HTP methods so that we can apply them.
- The opportunities arising from this new approach with the precision of small destructive sampling will smaller samples, which will be transformative.
- Any breeding programme aims for high adoption, and for boiled yam, taste and mealiness are key traits and for pounded yam smoothness and stretchability.
- Assessing consumer-preferred traits for boiled and pounded yam requires quick clear steps.
- Prior to the AfricaYam project yam selection and crossing was based on agronomic performance and pests and disease resistance. Improved cultivars are rarely adopted if food quality was poor. There is a new orientation towards cooking quality, where quality thresholds correlate well with pest and disease tolerance (e.g. Labokwa as good tasting variety), which will allow integrating new traits give new information for the yam programme.

Some general comments were also raised as follows:

- Through integrating food sciences involvement 20% input will lead to 80% success.
- This workshop has helped remove a barrier between the two silos of breeding and food science and to engender both mutual respect and a collaborative spirit, although many loose ends need tying up.
- As the One CGIAR reforms are implemented, quality will be an even more important consideration.
- An RTB Yam-breeding platform could be formed by the team represented in this workshop, where clients could request centralized services for breeding, although cost structures need to be delineated.

- Now is time for breeders to work with food scientists. However, even before harvest food scientists need to understand the implications of physiology, agronomy and morphology, so scientists need not wait until harvest before elucidating new steps or aspects in the breeding pipeline. This could involve more workshops/interactions between food scientists and breeders, including webinars or lectures. Two-way communication is needed immediately, for example via a roundtable like this forum, to share data, knowledge, information and other resources.
- As both AfricaYam and RTBfoods come to an end, we need to organize a joint project using the Yam Excellence in Breeding (YEIB) platform, product profile delivery and proofs-of-concept. This will be important when thinking about the June 2022 evaluation. By mid-2022 we time will know more.

2.6.4 Workshop closing comments

Professor Noel Akissoé (UCA-FSA, Benin) proposed a general vote of thanks, seconded by Dr Dominique Dufour (Cirad, France). Dufour reminded participants that planning for this workshop began two years ago after an IITA lab workshop with AfricaYam. Over such a short time the workshop has demonstrated what RTBfoods is doing in food science for breeders. He also acknowledged the project team, especially Cathy Méjean and Eglantine Fauvelle, and reminded the participants that the best of West Africa is here altogether. The next steps will include agreeing on how to improve the research domain operations and develop common aims. Interdisciplinary discussions have been critical for yam evaluation, and this workshop has been a real success. He concluded by inviting participants to continue this joint discussion in the future.

In extending his vote of thanks, Dr Asrat AMELE (IITA, Nigeria) expressed his anticipation for the energy and passion of the participants, which can only prompt young breeders' successes. The team needs to be smart in its breeding activities to produce high-quality, high-yielding genotypes. He expressed the hope and expectation that what has been learned will be applied to breeding programmes, so that in the next meeting there may be early success stories to recount. He also highlighted that most breeders' funding gives only a nod to considering food quality, but initiatives like RTBfoods may help to redress this imbalance. He concluded with another vote of thanks to UCA. Finally, Professor Dansi Alexander Brorave (UAC, Benin) emphasized the critical importance of food quality in adoption, affirming the primary consideration of food quality as a basis to select varieties before considering yield or disease tolerance. He also added his vote of thanks for Cirad, Dr Dufour and the AfricaYam team.

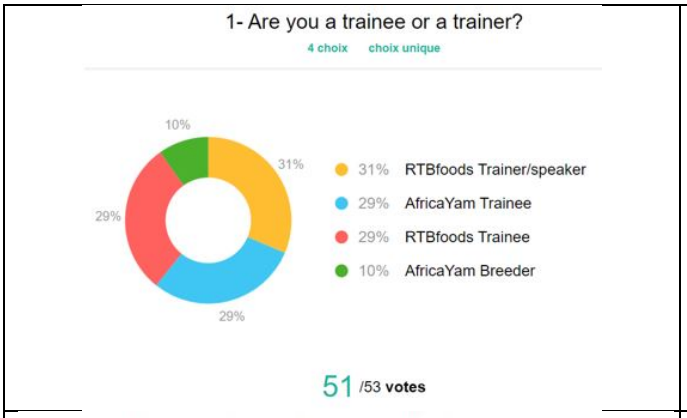
Workshop participants then completed the workshop evaluation, a synthesis of which is presented in section 3.

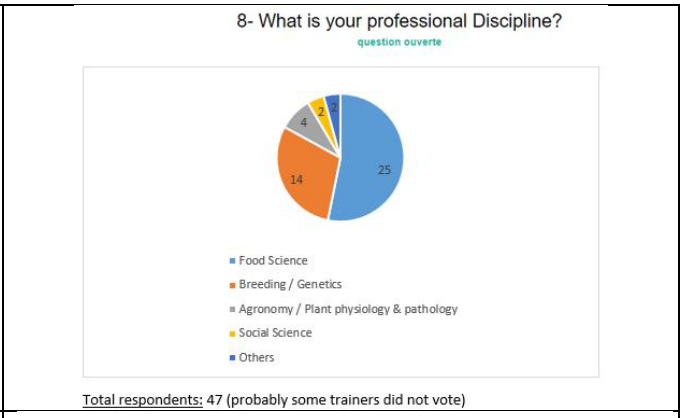
In a workshop graduation ceremony at the end of the workshop, trainees were provided with certificates of attendance and diplomas. As an incentive for completing the workshop evaluation, each trainee was also given a yam-pounding pestle and mortar made with African hardwood, and these were used as 'percussion' instruments in a spontaneous celebratory session of singing and dancing, in true West African style.

3 MEETING EVALUATION

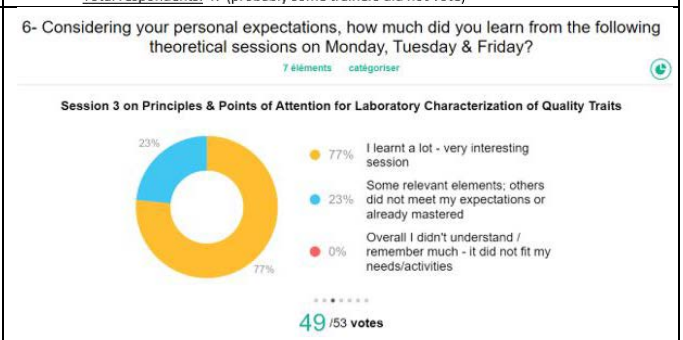
53 out of 67 participants (of which 30 were trainees) (79% response rate) completed the online meeting evaluation form. Figure 15 provides a snapshot of the charted feedback which corroborates the positive feedback already received, that meeting participants were largely extremely satisfied or satisfied, and regarded the training as relevant to their needs. The quantitatively scored assessments were also supported by some open questions of relevance, learning level, next steps and miscellaneous comments which are summarized below figure 15.

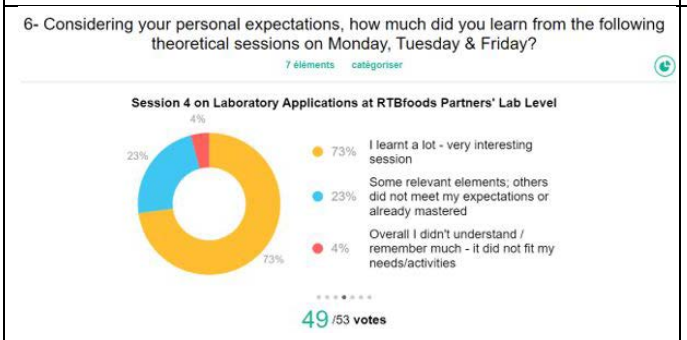
3.1 Evaluation overview

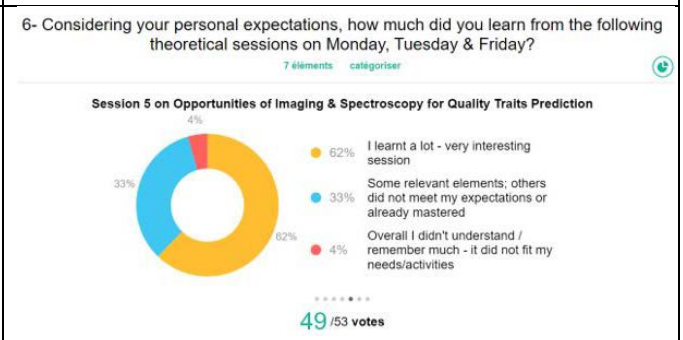


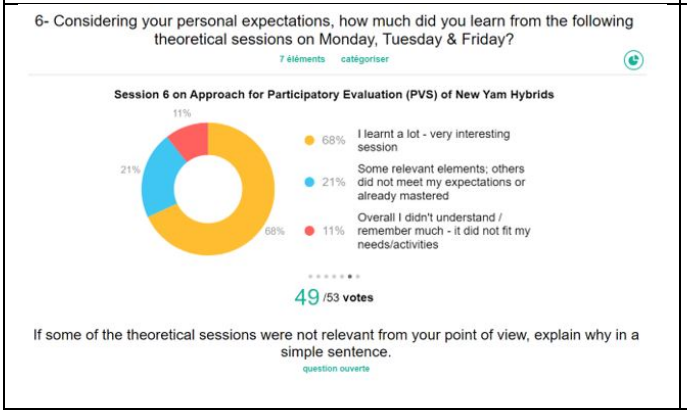


Total respondents: 47 (probably some trainers did not vote)









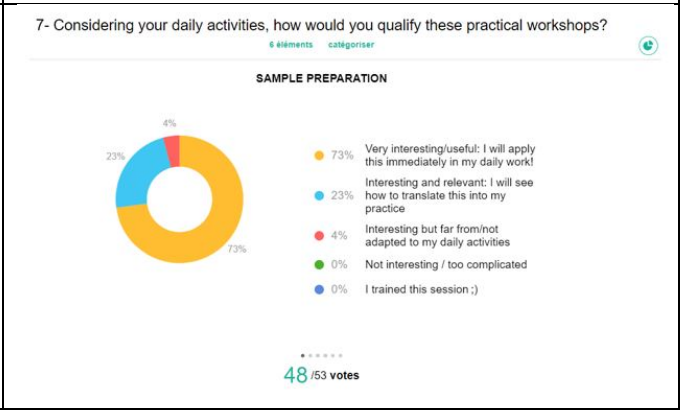


Figure 15 Snapshot of training participants' evaluation of the Yam quality evaluation workshop, in terms of relevance and usefulness

3.2 Open questions synthesis

Respondents were asked to also answer open questions as follows :i) briefly list **three new things** they had learned during the workshop; ; ii) which **specific aspects** would they be applying to their daily activities; iii) what **next steps** would be needed to facilitate applying their new learning; iv) to comment on the **relevance** of the theoretical and practical sessions to the trainees' professional contexts, v) what were the **main highlights** of the workshop, and vi) to provide any other **complementary comments**.

3.2.1 New learning

Figure 16 summarises the responses, where many identified QDA sensory evaluation and data management along with statistical analysis as the most quoted new learning. The next most significant learning area was in the interdisciplinary approach which included the several aspects of gender; WP5

activities; and strengthening links between breeders and food scientists. A third significant area of learning was understanding better the nuances associated with traits definitions and analyses, including in terms of thresholds and descriptors. Texture analysis, image/HSA analysis (for traits prediction) and NIRS were also quoted by several respondents. Two other key areas of learning were in approaches to better integrate consumer acceptability and trait correlations.

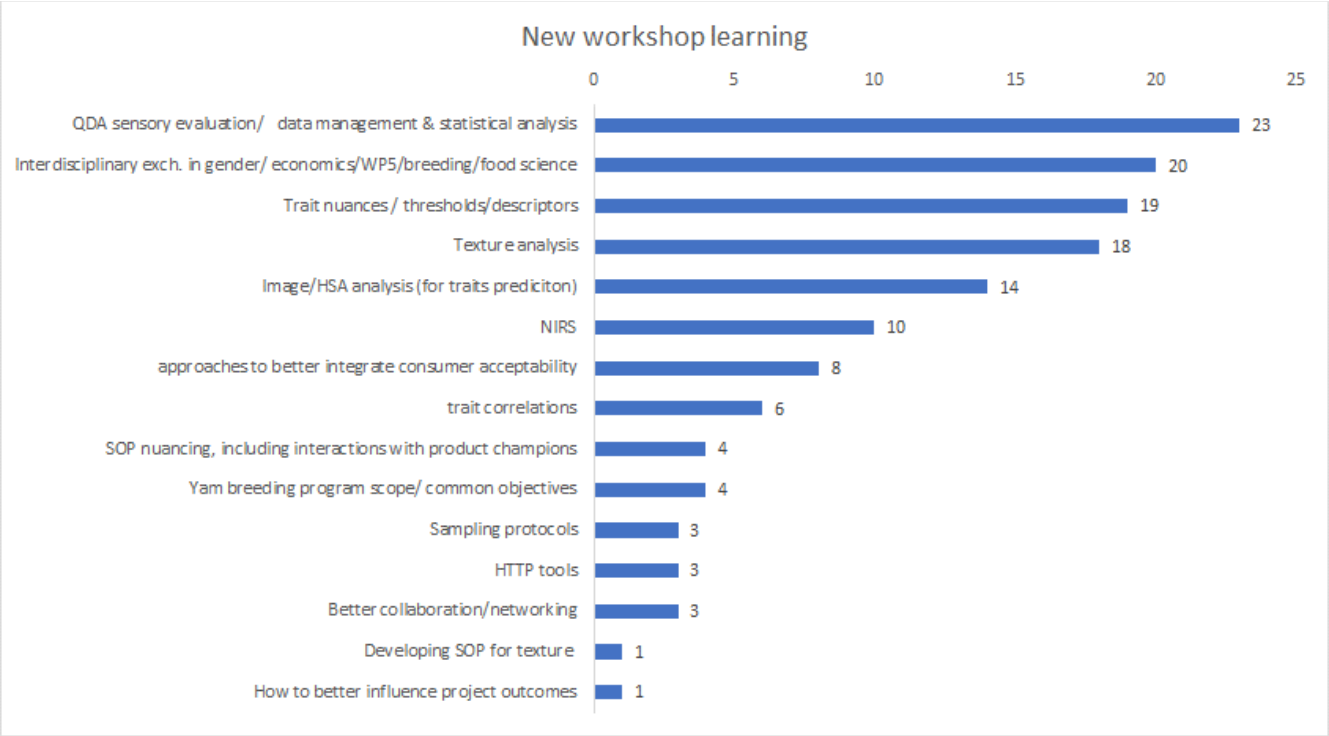


Figure 16 Workshop new learning

3.2.2 Which specific aspects will you apply in your daily activities?

Figure 17 summarises respondents' expressed intentions to apply optimized sensory evaluation and texture measurements (texturometer /other rheological); harmonize, validating and applying SOPs (including vocabulary harmonization); use image analysis/ optimized data processing; apply new sampling techniques, sample preparation; apply new sample and sensory data collection analysis; adopt more participatory approaches; consider more nuanced approaches to traits predictions (based on WP1 results); synergize food science and breeding; focus on HTTP, ITPA and STPA validation; apply tools that predict good qualities early in the breeding cycle.(including NIRS); review their experimental designs; combine lab techniques for assessing consumer testing trained panelists and consumer testing in the field; use the MS excel statistical tool in data analysis, and finally provide training and retraining for panelists

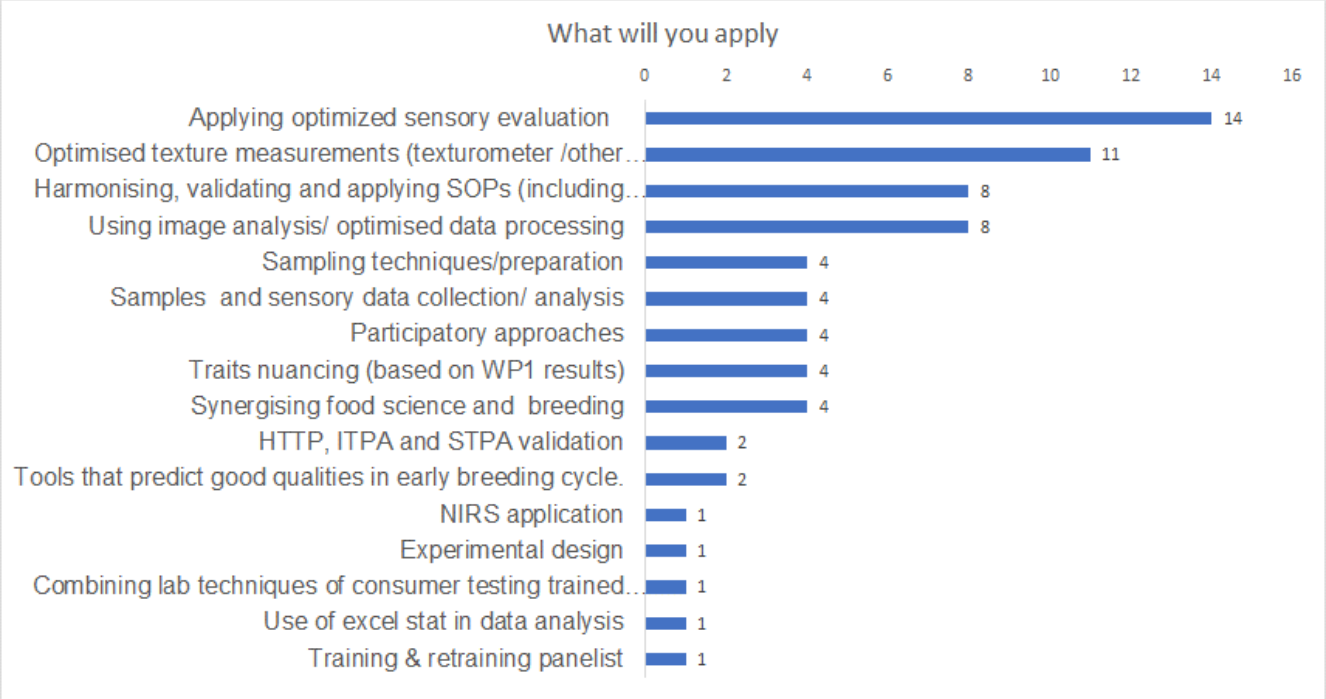


Figure 17 Trainee intentions to apply specific aspects of their learning

3.2.3 What next steps would facilitate applying new learning?

Feedback on personal next steps fell into five main areas: specific technical activities; planning; further work on the SOPs; further training and equipment or infrastructure upgrades (as summarised in Fig 18, and described in more detail in table 4)

Figure 18 Respondents suggested personal next steps

Table 4 Proposed next steps for respondents

Area		Activity	
Equipment infrastructure	4	upgrading of laboratory infrastructure/ equipment	2
		need NIRS	1
SOPs	8	Accessing, optimising, validating and direct application of SOP for most tools and procedures	3
		SOP for sample preparation	1
		SOP for textural analysis	1
		SOP for sensory	1
Further training	13	review presentations and learning	2
		Transfer of /learning / technology to teams	4
		panel training for repeatability	1
		more practical session on image analysis	1
		build on gender work/ training	1
		excel stat / stats analysis	2
		texture analyser	1
		Sensitizing co-workers & panellists to the improved approach	1
		writing scientific papers.	1
Planning	14	meeting to plan period 5 activities incorporating priorities traits for our different product profiles	2
		boost Motivation and commitment	1
		Synergising with social and food scientists.	1
		Liaise with team to implement workshop learning in our breeding program	1
		Training on available equipment in our Lab	1
		Integration of multidisciplinary approach	1
		review SOPs	1
		Practicing, connecting with those who have successfully applied it (4)	1
		Have a meeting with the Breeders/ food scientists	2
		Update workplan	1
		Reorientation and reorganisation of project team for more effectiveness	1
Specific quality evaluation next steps	17	Consumer tests on 15 hybrids	1
		apply laboratory analysis.	1
		Apply statistical tools in analysing sensory and textural analysis	1
		Analysing other biophysical attributes associated with ITPA and STPA	1
		Textural measurements	2
		Develop HSI batch analysis using R and Python	1
		analyse sensory data	1
		traits nuancing	1
		Work on proof of concepts to establish possible correlation between traits.	1
		Using it for the screening of genotypes	1
		Making sensory reports available	1
		Must always sensory evaluate food for its acceptance by consumers	1
		establish a sensory panel	2
		establish an image lab	1

3.2.4 Theoretical sessions' relevance

The majority of those respondents offering feedback suggested that all theoretical sessions were relevant. They also suggested the theoretical sessions supported the SOP guidelines and prepared trainees well for the practical sessions. Furthermore, workshop interactions also helped familiarize with the breeding process. They also found textural and sensory analysis and imaging sessions highly relevant.

However, one trainee suggested a need for more supporting documentation to complement understanding. Also, several respondents suggested that NIRS and image analysis are complex and further training would be needed. Less than 5-10% of respondents claimed some of the subject matter was too remote, that the NIRS angle less relevant, and some sessions were overly detailed/ specific. (see figure 19)

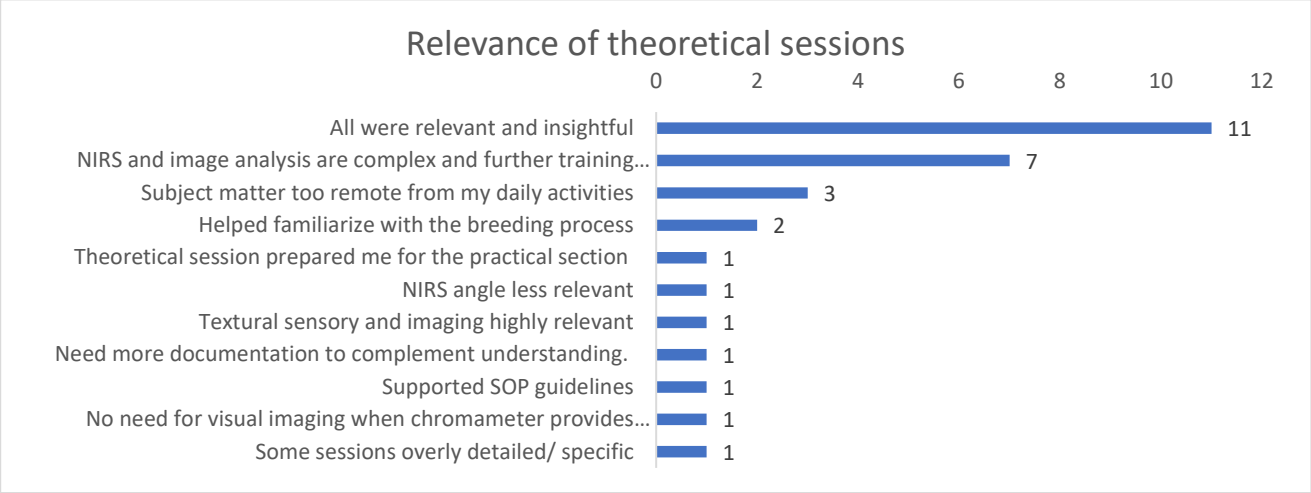


Figure 19 Relevance of theoretical sessions

3.2.5 Practical relevance

The majority of those respondents offering feedback also suggested that all practical sessions were relevant, with only one respondent (a breeder?) saying they were not immediately relevant

They suggested that these practical sessions were the most important part of workshop, providing great insights and an opportunity for more effective and efficient outputs. Whilst the sessions were relevant, some aspects were just newly introduced, so time is needed to assimilate the learning. Single respondents voiced the following concerns (which may be more widely experienced): i) the NIRS and imaging sessions were too technical, and is not widely available; ii) although relevant, the data analysis sessions need further training on software use; iii) some equipment is not available in respondents' laboratories; iv) there was not enough time for greater hands-on practical learning (next time will consult website before workshop); v) the imaging training was more theoretical than practical; and vi) some packages presented are not easily accessible.

3.2.6 Training highlights

Respondents were asked to list any particular training highlights. Many expressed their appreciation for the training opportunity and for the proposed multi-stakeholder approach involving food and social scientists along with breeders, farmers and consumers, especially for the greater focus on linking breeding with consumer preferences. Around 20% respondents mentioned the improved facility for effective traits correlation and prediction with respect to raw, material, and intermediate and final products, as well as screening techniques. The training to improve sensory evaluation to align textural and sensorial properties was also highly appreciated. as well as the information on statistics and data

analysis. Sharing best practice, the use of HTTP to enhance operations, and the ongoing commitment to continuously training panelists were also listed by a few respondents.

3.2.7 Other comments

Respondents expressed general appreciation for donors, organizers, and project teams and their members, and for a well-organized, thought provoking and insightful workshop, which has ensured a 'new romance and marriage between food science and breeding'. Respondents highlighted a need for greater time allocation for practical sessions in future trainings, and expressed a desire for this type of workshop to be organized periodically. Trainers should ensure full participation of trainees for better involvement, with coaching. It was also noted in hindsight that this workshop could have been done at the beginning of the program. Requests were made for the training materials to be made available for personal consumption. Respondents look forwards to more future interactions, and suggest such a training could be reprogrammed for other RTB crops crop (cassava, potato, etc.).

4 RECOMMENDATIONS

The workshop presentations, Q&A sessions and panel discussions stimulated dynamic and useful exchanges on a wide range of yam quality evaluation issues. These covered surveys; sampling; sample preparation; data collection; laboratory analysis; data analysis and interpretation; specific quality traits; selection and breeding. These are reported in detail section 2, and highlighted as recommendations below.

Participants reaffirmed their commitment to producing a set of standardized user-friendly yam-quality evaluation protocols for an agreed set of key traits, across a wide range of cultivars, in addition to accommodating user preferences. These are being based on objectively collected, robust and triangulated data, the research for which will integrate contributions not just from food scientists but also from breeders and social scientists. Where needed, future smart experimental designs should integrate single poly-instrumental experiments that quantify multiple textural parameters for key trait proxies, using well- and regularly-trained multi-disciplinary teams, who can apply the required technical competencies for quality evaluation (including data analysis and image production). This requires adequate human and other resources, including time, where funding should equitably consider food quality with crop performance, and other solicit collaborators such as universities

RTBfoods is leading a new approach towards quality evaluation, where quality thresholds will correlate well with crop performance. This approach is removing the traditional barriers between the two silos of breeding and food science, engendering mutual respect and a collaborative ethos.

Key partners for yam and other RTB quality evaluation, within and beyond the reforming One CGIAR framework should propose further interactions including roundtables, webinars, lectures symposia, and workshops involving a broad range of stakeholders, especially food and social scientists, and breeders. A key outcome of such interactions would be a joint follow-on RTB/Yam quality evaluation project that further promote adoption of improved yam cultivars at scale. Collaborators would need to agree on how to improve the research domain operations and develop common aims.

These recommendations summarize the interactions during Q&A sessions and panel discussions:

1. **Male bias** in breeding needs redressing

4.1 AfricaYam partner experiences on quality assessment & PVS

1. **Selection** of key breeding traits **should be fine-tuned** to allow for an inclusive approach which will consider the issue of gender bias in breeding by consulting women in the process
2. Food quality traits for both **international and domestic preferences** (including woman-farmers) should be simultaneously recognized
3. More clarity is needed on **how sweetness of pounded yam is measured**
4. **Taste and aroma** traits should be considered **separately**, where taste is the highest priority
5. Sensory panelists' **sensorial evaluation skills should be updated annually** by periodic training and re-training
6. **Fried yam** should be considered alongside boiled and pounded yam in quality assessments
7. A **parameter list** should be drafted to be used across all programmes
8. All national RTBfoods partners across 80 locations need a **set of common/standardized yam-quality evaluation protocols for an agreed set of key traits, accommodating user preferences**

4.2 Tools for Yam quality evaluation within WPs1, 2 & 3

4.2.1 WP1: activities for Yam

1. There is a need for robust **triangulation**, including breeders' inputs
2. Consumers' **willingness to pay** for superior traits needs to be further investigated
3. **Awareness building** is needed to promote new varieties and their adoption.
4. **Crossing characteristics** should be finalized before sharing with breeders,
5. PMU should consider:
    a. when and how to include **breeders**, especially for survey teams
    b. how **survey respondents** should be **incentivized**
    c. ways of **reducing time** required for survey work
    d. how to avoid **respondents** feeling **patronized**
6. Analysts should consider how to effectively manage evaluations of important **traits common to both boiled and pounded yam** product profiles including texture/mealiness, aroma, color (whiteness) and ease of peeling
7. **Tuber-size market requirements variations** need accommodating - there are already some good varieties found in the markets as examples
8. **SOPs need further nuancing** to better consider post-cooking/ processing discoloration/ color changes, and smoothness

4.2.2 WP2: principles for characterization of Yam quality

9. Texture analyses (**TA), needs time** for validation, willing collaboration, and fluent statistical knowledge.
10. A single experiment could **quantify multiple textural parameters**,
11. **Blending samples** can provide more reproducible results with higher statistical accuracy
12. The challenge of **maintaining consistent <u>temperatures</u> during texture measurements** could be partly addressed by:
    a. staggering testing in 10-minute batches,
    b. set all samples at elevated temps (e.g. in water bath at 50^{o} C).
    c. Temperatures being recorded during and after cooking, and analysts considering delaying test for a standard amount of time (e.g. by using controlled-temperature boxes allowing performing all tests at the same temperature)
    d. Sample temperatures being maintained by the use of Styrofoam sample boxes

e. keeping samples together in temperature control equipment
f. by ensuring short distances between preparation and measurement. A practical approach will facilitate logistics.

13. A fixed **cooking protocol is needed for managing different varieties**' cooking kinetics, and establishing optimal cooking times.
14. To better manage the wide variation in product consistency, evaluators need to **understand the product and calibrate their sensory analyses**, as each yam variety has different properties.
15. Analysts should **include results from all tuber sections** as most consumers do not discriminate, and this could affect acceptance.
16. Analysts need to know **how best to validate their textural analysis** especially when sensory analysis is to be correlated with textural analysis
17. In *establishing thresholds* after textural measurements for quality traits for different genotypes, **analysts should conduct consumer and discriminatory tests that assess a wide range of cultivars**. After establishing all WP2 QDA results, analysts should liaise with breeders to establish 'good', 'medium' and 'poor varieties' then conduct textural measurements to determine threshold ranges for calibration.

4.2.3 WP2: lab applications for Yam quality analysis

18. In pounded yam lab analysis:
    a. measuring '**instrumental color'** could be a useful HTPP method for color
    b. both **yam pasting properties and instrumental texture profile analysis** (ITPA) could be useful for medium throughput protocols (MTP).
19. For fresh, boiled and pounded yam evaluation work, there is a need to:
    a. **explore relationships between sweetness and cooking time**,
    b. develop and calibrate **models to measure other yam quality traits**
    c. look more closely at yam's **biophysical properties**.
20. In yam cell-wall studies **NSP methylation levels** can be measured by NIRS, which could provide **a useful means of characterizing yam cooking behavior**.

WP2 Discussion Panel: How to Translate into Medium-throughput Protocols for Implementation in Yam Breeding Pipelines?

21. There is a need to represent the whole range of sensory traits with **key proxies** and complement sensory panels with a **poly-instrumental approach**. For example, to evaluate texture, a single SOP should be able to discriminate between all cultivars, using robust criteria. (e.g. for boiled yam, the pre-workshop meeting group had identified 8 key traits from 40 traits). A **follow-up meeting is needed** to translate their considerations.
22. More interactions are needed with **breeders and social scientists**. Evaluation can be slow and costly, hence a need to prioritize different sectors of users, and especially to generate more breeders' buy-in.
23. **Water absorption, cooking time,** and **cooking and textural qualities** need to be prioritized,
24. Further **harmonizing the SOPs** will allow reproducibility and add more value than just sensorial understanding, and this should be done before sharing with breeders.
25. A **new platform** could stimulate greater interactions between WP1, WP2 and breeders, as well as providing greater access to protocols by breeders.
26. **Evaluation practices** such as lab protocols need to be **user-friendly for breeders and other field users**, so portable equipment should be made available, and the more easily measurable traits given priority.

4.2.4 RTBfoods WP3: high-throughput prediction of quality traits

27. **Blending samples** before NIRS measurement can provide more reproducible results with higher statistical accuracy
28. Measurements for **texture evaluation** in boiled yam and gari **need improvement**, and not all textural qualities can be evaluated in this way. This technology allows for discriminating between 'good' and 'poor' yam varieties
29. It may be possible to evaluate yam **biophysical characteristics**
30. The **coefficient of determination** needs additional criteria such as standard error of prediction (SEP). If the R^2 is fair, but SEP is also low, this indicates a need to improve on the model. Also, prediction of wet samples is often less accurate than for dry samples
31. As new variants are developed, the **dataset will need extending** to account for variability during measurements.
32. **Breeders, food scientists, and social scientists** must together to rank and streamline key traits for easy adoption
33. **Correlating sensory and biophysical traits** needs further work before approaching breeders, and **results from newly-emerging sensorial analysis** will also need to be integrated.

4.3 Yam quality characterization- sampling, preparation, sensory & textural analyses

34. **Panel criteria** should include availability, reliability, punctuality, and willingness.
35. The need for **sensorial training**, and scouting for **inherent capacity** for sensorial analysis should be emphasized.
36. **Panel training takes time**, and **repeat trainings** are needed to ensure consistency.
37. Guidance could be strengthened on **producing meaningful, analyzable images**.
38. Evaluators need to:
    a. better understand those **areas where quality evaluation errors** might be made.
    b. have more exposure to/ more time for **hands-on evaluation** experience
    c. have more opportunity to establish **useful correlations with sensory data**
    d. **remain objective** in terms of methodology, literature, and rigorous controls evaluation methods.
39. Evaluators need more **guidance on data analysis and interpretation**, including perhaps within the SOPs
40. Analysts should consider **how to approach those elusive thresholds** proving difficult to identify.
41. PVS approaches should integrate **missing traits of flour yield, and processing times and quantities**.
42. PMU may consider even further **exploiting the multiple synergies** between WP1 and WP5 that have emerged.
43. Trials teams should **optimize trial replicate numbers** (depends on the size of trials– less in larger fields, but normally 2-3 replications after which the roots can be bulked. Three processors with 3 replications according to the SOPs would be sufficient, and results from WP5 research helps build external validity of lab evaluations (eliminating drudgery and processing time). So only for advanced clones are three processors per location necessary.
44. **Time intervals between harvest and lab-processing should be minimized** (e.g. to avoid moisture loss). Efforts to establish a mobile lab facility are ongoing, but it can be difficult to accommodate bulking. A simple solution is to send root samples immediately to the lab.
45. The **minimum number of participants and clones in consumer testing** should be clarified. Variability can be accommodated with smaller samples where testing promising clones only. It is challenging to evaluate more than five clones at a time.
46. The term '**consumer testing' should be clearly defined** for a common understanding to include farmers' evaluating material, and formal consumer testing. A more rigorous testing scope should

accommodate rural and urban, gender, region and so forth– IITA, for example normally interacts with local communities. Food scientists and breeders must decide whether or not breeders' work includes consumer testing.

47. The **new tools emerging from RTBfoods** should be **available for breeders** when testing these materials at point of varietal release to facilitate/ promote adoption. These must also **accommodate cultural considerations and address policy requirements**.

4.3.1 Breeding more effectively for yam quality: panel discussion

48. Food scientists need tools and breeders need traits, but these **traits need prioritizing and correlating to maximize adoption**. Such work could also be supported by **cooking demonstrations**.

Q1 Through what you saw this week, what is missing for your own programme, and what is not relevant?

49. Yam-breeding programmes need **adequate human resources for trials, supported by increased mechanization**.
50. Quality traits of many varieties must inform selection, and this **more trainings like this** will enhance cultivar improvement. RTBfoods predictive tools will boost adoption.
51. **Breeders' methodologies need standardizing**
52. Strengthening links between breeders and food scientists will add value but **time is needed** for this.
53. Sensory evaluation tools will help fast-track the hitherto cumbersome and lengthy breeding process. **Collaborators for sensory evaluation must be onboard**. The workshop helped better understand WP1 issue of harmonizing nomenclature to capture differences

Q2 What one thing will you implement in your programme as soon as you reach home.

54. Despite scant government resources we need to employ food scientists to help with screening as a team, so perhaps we can **access other resources such universities** to achieve this. Although it should be easy to download all the SOPs and to apply them, lack of human resources will continue to constrain the breeding programme, unless we **invest in human resources**
55. The fast-approaching **yam harvest will provide a timely opportunity to use PVS learning** to assess cultivars vegetative traits and harvest rates
56. Breeding is incremental and linear, and in assessing agronomic traits, breeders we must also consult with food scientists to build **multi-disciplinary teams to implement best practice** in the best labs in West Africa
57. The workshop learning will inform **a new food science approach** of sampling and sample preparation for textual analysis to improve current approaches
58. The strong RTBfoods team provides the means to see and reflect on how to improve yam breeding, considering personal assumptions and which tools can be used in a modest lab context. There is perhaps a **need to develop a collaborative breeding strategy**. The perception that breeders must do everything in isolation has shifted with the realization that these tools can be applied to improve the work.

Q 3: How do we plan to integrate these tools and how can we rank these tools

59. Breeding needs **multidisciplinary teams and roles**, all requiring a vehicle by which we need to understand what our product and what blueprint or map can will specify what we can deliver with such teams. For example, in boiled yam where chewing quality or hardness are key traits, all the team needs to be involved: breeders agronomists pathologists food scientists and social scientists. **RTBfoods needs to deliver its HTP methods** so that we can apply them.
60. The opportunities arising from this new approach with the **precision of small destructive sampling with smaller samples**, which will be transformative.
61. Any breeding programme aims for high adoption, and for **boiled yam, taste and mealiness should be considered as the key traits and for pounded yam smoothness and stretchability**.

62. Assessing consumer-preferred traits for boiled and pounded yam requires **quick clear steps.**
63. Prior to the AfricaYam project yam selection and crossing was based on agronomic performance and pests and disease resistance. Improved cultivars are rarely adopted if food quality was poor. There is a **new orientation towards cooking quality, where quality thresholds correlate well with pest and disease tolerance** (e.g. Laboko as good tasting variety), which will allow integrating new traits give new information for the yam programme.

general comments

64. Investing 20% food sciences input will lead to 80% success.
65. Workshop learning and interactions should be applied to **remove the barrier between the two subjects of breeding and food science** and to engender both **mutual respect and a collaborative spirit**, although many loose ends need tying up.
66. As the **One CGIAR reforms** are implemented, quality will be an even more important consideration.
67. An **RTB Yam-breeding platform should be formed** by the team represented in this workshop, where clients could request centralized services for breeding, although **cost structures need to be delineated**.
68. Now is time for breeders to work with food scientists. However, even before harvest food scientists need to understand the implications of physiology, agronomy and morphology, so scientists need not wait until harvest before elucidating new steps or aspects in the breeding pipeline. This could involve **more workshops/interactions between food scientists and breeders, including webinars or lectures**. Two-way communication is needed immediately, for example via a **roundtable** like this forum, to share data, knowledge, information and other resources.
69. As both AfricaYam and RTBfoods come to an end, we need to **organize a joint project** using the yam excellence in breeding (YIB) platform, product profile delivery and proofs-of-concept. This will be important when thinking about the June 2022 evaluation. By mid-2022 we will know more.
70. RTBfoods partners must **agree on how to improve the research domain operations and develop common aims**.

Breeders' **funding should equitably consider food quality with crop performance** and initiatives like RTBfoods may help to redress this imbalance.

It is also recommended that PMU reviews the workshop evaluation feedback, especially next steps for specific technical activities; planning; further work on the SOPs; further training and equipment or infrastructure upgrades (as summarised in Fig 18, and described in more detail in table 4)

Group photo

5 APPENDICES

5.1 Annex 1: Meeting schedule

AfricaYam/RTBfoods Training on Yam Quality Evaluation
22 - 26 November, 2021 - Cotonou, Benin

Time CET	Monday 22 November	Tuesday 23 November	Wed 24 November
07:45	Buses departing from Ibis Hotel & Hotel du Lac	Buses departing from Ibis Hotel & Hotel du Lac	Buses departing from Ibis Hotel & Hotel du Lac
08:30	Registration	Wrap-up Day 1 & Pres. Day 2 (V. Johnson) 5' RTBfoods/WP1 - RTBfoods Methodology for Gendered Food Product Profiles (L. Forsythe) - 15'	Field Trip
09:00	UAC/FSA Welcome (FSA Dean)	Synthesis on Boiled Yam & Pounded Yam Quality Characteristics (T. Madu + O. Oroniran) - 10'+10'	
09:20	UAC/FSA Overview on Yam Projects (N. Akissoe)	Q&A Session on Previous Presentations	
09:40	French Embassy & FSA Rector	Panel Discussion Panellists: N. Akissoe, B. Otegbayo, O. Oroniran, T. Madu, B. Teeken Moderators: H. Chair & G. Ngoh	
10:00	Family Picture		
10:20	Tea/coffee break	Tea/coffee break	
10:40	Program Presentation & Participants Interactions (E. Fauvelle)	RTBfoods/WP2 - Sensory Profiling: Principles & Points of Attention (C. Bugaud)	
11:00		Texture Profiling: Principles & Points of Attention (L. Dahdouh)	
11:20	AfricaYam & RTBfoods Overview (P. Adebola & D. Dufour)	Physico-chemical Analyses: Principles & Points of Attention (C. Mestres)	
11:40	AfricaYam Experience-Quality Assessment & PVS - at UAC (A. Dansi & I. Yetome)	Q&A Session on Presentations	
12:00	- at IITA, NRCRI & EBSU (A. Amele, J. Obidiegwu, H. Oselebe)	RTBfoods/WP2 - Lab Applications: - at UAC-FSA (L. Adinsi)	
12:20	Q&A Session on Previous Presentations	- at Bowen University (B. Otegbayo)	
12:45	Lunch	Lunch	

AfricaYam/RTBfoods Training on Yam Quality Evaluation
22 - 26 November, 2021 - Cotonou, Benin

Time CET	Monday 22 November	Tuesday 23 November	Wed 24 November
12:45	Lunch	Lunch	
14:00	AfricaYam Exp. - Quality Assessment & PVS: - at CSIR-CRI (E. Otoo) - at SARI (E. Chamba)	- at IITA (M. Adesokan)	
14:20	- at CNRA (M. A. Kouakou) - at CIRAD-Guadeloupe (G. Arnau)	- at NRCRI (U. Chijioke)	
14:40	Q&A Session on Previous Presentations	- at INRAe (A. Duthell, L. Desfontaines, D. Rinaldo)	
15:00	AfricaYam Panel on Quality Assessment Panellists: A. Amele, J.Obidiegwu, M. A. Kouakou, A. Dansi, E. Otoo, E. Chamba, H. Chamba, H. Oselebe, H. Chair Moderators: P. Adebola & D. Dufour	Discuss° Panel: How to Translate into Medium throughput Protocols for Implementation in Yam Breeding Pipelines? Panellists: L. Adinsi, B. Otegbayo, U .Chijioke, M. Adesokan; Moderators: B. Maziya-Dixon & E. Otoo	Pre-departure PCR Testing
15:20			
15:40		Tea/coffee break	
16:00	Tea/coffee break	RTBfoods/WP3 - NIRS for Quality Traits Prediction: Opportunities & Challenges in Practice (F. Davrieux, E. Alamu)	
16:20	FSA campus tour & lab visit	Opportunities of Imaging (D. Cornet)	Return to the hotels / Free time
16:40		Possible Applications of Hyperspectral Imaging to Predict Yam Quality Traits (K. Meghar)	
17:00		Q&A Session on Previous Presentations	
19:00	Welcome cocktail (Ibis Hotel)		

AfricaYam/RTBfoods Training on Yam Quality Evaluation
22 - 26 November, 2021 - Cotonou, Benin

Thursday 25 November	Friday 26 November	Time CET
Buses departing from Ibis Hotel & Hotel du Lac	Buses departing from Ibis Hotel & Hotel du Lac	07:45
Wrap-up Day 2 & Presentation Day 3 (V. Johnson)	**Wrap-up Day 3 & Presentation Day 4** (V. Johnson)	08:30
Pratical exercice 1: Presentation of UAC-FSA SOPs for the Characterization of Boiled Yam Quality: Sampling & Sample Preparation for Steaming of Yam Tubers for Lab analyses (incuding NIRS) *3 groups in parallel* (FSA team: I. Djibril, L. Adinsi, F. Hotegni)	**Practical exercise 3:** Analysis of Sensory Data: Application on a RTBfoods Dataset, as an example *(precise focus to be confirmed by FSA team)* (L. Adinsi, N. Akissoe, I. Djibril, C. Bugaud)	09:00 09:20 09:40 10:00
Tea/coffee break	**Tea/coffee break**	10:20
Pratical exercice 2 on boiled yam (3 workshops in parallel): A/ Textural measurements (extrusion & compression tests) *groups of 6 trainees max (30')* (I. Djibril, F. Hotegni, J. Ricci) B/ Sensory analysis (QDA protocol) *groups of 12 trainees max (60')* (L. Adinsi, N. Akissoe, C. Bugaud) C/ Image Acquisition and Analysis & NIRS Spectra Manipulation (D. Cornet, K. Meghar, E. Alamu) *groups of 12 trainees max (60')*	**Practical exercise 4:** Relationships Between Sensory Data & Textural Parameters *(precise focus to be confirmed by FSA team)* (L. Adinsi, I. Djibril, N. Akissoe)	10:40 11:00 11:20 11:40
	RTBfoods/WP5 - Methodology for Participatory Evaluation (PVS) of New Yam Hybrids (G. Ngoh Newilah, A Bouniol, A. Amele/J. Obidiegwu)	12:00
	Q&A Session on Previous Presentation	12:20
Lunch	**Lunch**	12:40

Thursday 25 November	Friday 26 November	Time CET
Lunch	**Lunch**	**12:40**
[to be cont.] **Pratical exercice 2 on boiled yam (3 workshops in parallel):** **A/ Textural Measurements (extrusion & compression tests)** *groups of 6 trainees max (30')* (I. Djibril, F. Hotegni, J. Ricci) **B/ Sensory Analysis (QDA protocol)** *groups of 12 trainees max (60')* (L. Adinsi, N. Akissoe, C. Bugaud) **C/ Image Acquisition and Analysis & NIRS Spectra Manipulation** (D. Cornet, K. Meghar, E. Alamu) *groups of 12 trainees max (60')*	**RTBfoods Ontologies & Database Management - Ontologies for Yam Food Quality Traits** (A. Aslimwe) **Storage of Yam Quality Data into YamBase** (A. Afolabi)	14:00 14:20
	Q & A Session on Presentations	14:40
	Informal meetings between participants	15:00 15:20
	Tea/coffee break	**15:40**
Tea/coffee break	**Discussion Panel:** **Perspective to include End-User Preferences into Yam Breeding Pipelines (AfricaYam & RTBfoods collaborations)** **Panellists:** RTBfoods & AfricaYam breeders **Moderators:** H. Chaïr & M. Adesokan	16:00 16:20 16:40
General Debriefing (all trainees & trainers)	**Meeting Evaluation & Closing Speech** (P. Adebola & D. Dufour)	17:00
Dinner at La Cabane du Pêcheur		

5.2 Annex 2: Yam workshop participant list

Gender	NAME	First Name	Institute	Country	Status
Ms	ACHONWA	Oluchi	NRCRI	Nigeria	Trainee
Mr	ADEBOLA	Patrick	IITA	Nigeria	Trainer/Speaker
Mr	ADESOKAN	Michael	IITA	Nigeria	Trainer/Speaker
Ms	ADETONAH	Sounkoura	IITA	Benin	Trainee
Mr	ADINSI	Laurent	UAC	Benin	Trainer/Speaker
Mr	AGBONA	Afolabi	IITA	Nigeria	Trainer/Speaker
Ms	AGHOGHO-IDHIGU	Cynthia	IITA	Nigeria	Trainee
Mr	AKISSOE	Noel	UAC	Benin	Trainer/Speaker
Mr	ALAMU	Emmanuel	IITA	Zambia	Trainer/Speaker
Mr	AMELE	Asrat	IITA	Nigeria	Trainer/Speaker
Ms	ARNAU	Gemma	CIRAD	France	Trainer/Speaker
Mr	ASIIMWE	Amos	Bioversity Int.	Uganda	Trainee
Mr	AYETIGBO	Oluwatoyin	CIRAD	France	Other
Mr	BOUNIOL	Alexandre	CIRAD	Benin	Trainer/Speaker
Mr	BUGAUD	Christophe	CIRAD	France	Trainer/Speaker
Ms	CHAIR	Hana	CIRAD	France	Trainer/Speaker
Mr	CHAMBA	Emmanuel	CSIR-SARI	Ghana	Trainer/Speaker
Ms	CHIJIOKE	Ugo	NRCRI	Nigeria	Trainer/Speaker
Mr	CORNET	Denis	CIRAD	France	Trainer/Speaker
Mr	DADONOUGBO	Ayenan Eric	UAC-FSA	Benin	Trainee
Ms	DAHDOUH	Layal	CIRAD	France-Reunion	Trainer/Speaker
Mr	DANSI	Alexandre	UAC	Benin	Trainer/Speaker
Mr	DARKWA	Kwabena	CSIR-SARI	Ghana	Trainee
Ms	DAVID-ABRAHAM	Folusho	EBSU-IITA	Nigeria	Trainee
Mr	DAVRIEUX	Fabrice	CIRAD	France	Trainer/Speaker
Ms	DIBY	N'Nan A. Sylvie	CNRA	Côte d'Ivoire	Trainee
Ms	DJIBRIL MOUSSA	Imayath	UAC	Benin	Trainer/Speaker
Mr	DOSSA	Komivi	CIRAD	France-Guadeloupe	Trainee
Ms	DUFIE	Irene	CSIR-CRI	Ghana	Trainee
Mr	DUFOUR	Dominique	CIRAD	France	Trainer/Speaker

Gender	NAME	First Name	Institute	Country	Status
Ms	EBAH	Catherine	CNRA	Côte d'Ivoire	Trainer/Speaker
Mr	EDEMODU	Alex	IITA	Nigeria	Trainee
Ms	FAKOREDE	Jeanette	UAC-UNSTIM	Benin	Trainee
Ms	FAUVELLE	Eglantine	CIRAD	France	Trainer/Speaker
Mr	FAWOLE	Segun	IITA	Nigeria	Trainee
Ms	FORESTIER-CHIRON	Nelly	CIRAD	France	Trainer/Speaker
Ms	HONFOZO	Laurenda	UAC-FSA	Benin	Other
Mr	HOTEGNI	Francis	UAC	Benin	Trainer/Speaker
Mr	JOHNSON	Vincent	Consultant	France	Trainer/Speaker
Mr	KENDINE VEPOWO	Cedric	CARBAP	Cameroon	Trainee
Mr	KOUABENAN	N'da Koffi Fabrice	CNRA	Côte d'Ivoire	Trainee
Mr	KOUAKOU	Amani Michel	CNRA	Côte d'Ivoire	Trainer/Speaker
Mr	KOUASSI	Antonin	CNRA	Côte d'Ivoire	Trainee
Ms	KUWORNU	Wilhelmina Elorm	CSIR-SARI	Ghana	Trainee
Ms	LAJOUS	Pascale	CIRAD	France	Other
Ms	MADU	Tessy	NRCRI	Nigeria	Trainer/Speaker
Ms	MAZIYA-DIXON	Busie	IITA	Nigeria	Trainer/Speaker
Mr	MBEGUIE-A-MBEGUIE	Didier	CIRAD	Côte d'Ivoire	Trainee
Ms	MEGHAR	Karima	CIRAD	France	Trainer/Speaker
Ms	MEJEAN	Cathy	CIRAD	France	Org. Committee
Mr	MESTRES	Christian	CIRAD	France	Trainer/Speaker
Ms	NANTONGO	Judith	CIP	Uganda	Trainee
Mr	NGOH NEWILAH	Gerard	CARBAP	Cameroon	Trainer/Speaker
Mr	OBIDIEGWU	Jude	NRCRI	Nigeria	Trainer/Speaker
Ms	ODOM-KOLOMBIA	Oluchi Lawrencia	IITA	Nigeria	Trainee
Ms	OFOEZE	Myriam	NRCRI	Nigeria	Trainee
Mr	OGNI	Ignace	UAC-FSA	Benin	Other
Mr	OKORONKWO	Justice	NRCRI	Nigeria	Trainee
Ms	OLATUNJI	Alice Adenike	IITA	Nigeria	Trainee
Ms	OLUSOLA	Theresa Tolulope	IITA	Nigeria	Trainee
Ms	OMODAMIRO	Rachel	NRCRI	Nigeria	Trainee
Ms	ORONIRAN	Oluyinka	Bowen Uni.	Nigeria	Trainer/Speaker

Gender	NAME	First Name	Institute	Country	Status
Ms	OSELEBE	Happiness	EBSU	Nigeria	Trainer/Speaker
Ms	OTEGBAYO	Bolanle	Bowen Uni.	Nigeria	Trainer/Speaker
Mr	OTOO	Emmanuel	CSIR-CRI	Ghana	Trainer/Speaker
Mr	OWUSU	Job	CSIR-CRI	Ghana	Trainee
Mr	OZI	Friday Ugadu	EBSU	Nigeria	Trainee
Mr	RICCI	Julien	CIRAD	France-Reunion	Trainer/Speaker
Ms	TANIMOLA	Abiola	Bowen Uni.	Nigeria	Trainee
Mr	TEEKEN	Bela	IITA	Nigeria	Trainer/Speaker
Mr	UDEAGBARA	Anthony Ikemefuna	NRCRI	Nigeria	Trainee
Mr	YELOME	Octaviano Igor	UAC	Benin	Trainee

5.3 Annex 3: Open questions feedback from workshop evaluation

Cite 3 new things you've learned/ discovered during this training
NIRS Texture analysis Image analysis
Link between hedonic and triangular test Needs of AfricaYam breeding program Point of advancement of SOP texture development of RTB Foods products
1. Possibility of better interpretation of chromameter data 2. Textural analysis procedure 3. Use of NIRS spectra data
1. How to take sensory data 2. How to analyse sensory data 3. How to analyse NIRs data using Chemflow
1. My understanding of Wp5 activities has improved 2. I have also gained more knowledge of yam breeding activities 3. I have also learnt more about statistics about linking sensory attributes to instrumental analysis
I have learned and discovered that the imagining system can be used to detect the exact color of our tubers which previously we only pick our colors visually
being an economist and gender specialist, i learned a lot - Textural measurement of raw yam, - interdisciplinarity work was very high, - More learn on G+ tool explained our colleagues. Now I can complete to fill the table sent by Lora. - and finally i can work with food scientist, breeder.
1. I have learnt the different between elasticity and stretchability. 2. I was able to know and understand the principles of texturability and its application 3. I equally understood the rating scales involves in the sensory evaluation. E.g. 1-10 scale
color is a key trait odor is different from aroma sample preparation should be standardized before measurements
This workshop improves my understanding on NIRS
QDA sensory analysis Correlation exists between QDA and texture analysis Number of samples has to be higher for consumer tests and that has to be done on different locations
I've learnt how to correlate the NIRS with Textural evaluation I've learnt the importance of HTTP in setting a standard for breeders I've learnt image profiling in color determination
Time of the day can affect evaluation of discoloration in yam How hyperspectral camera works Seeing things from the perspectives of the breeder
1. Basic vocabulary in yam quality assessment 2. Methodology of yam sensory evaluation 3. NIRS/ Image capture technology
Threshold determination
Calibration and use of a texture analyzer Analysis of image using imaging Sensory analysis of data

Cite 3 new things you've learned/ discovered during this training
NIRS in a jiffy Setting thresholds by consumer panels and instrumental texture profile analysis Establishing relationship between STPA & ITPA and Training sensory panel
As a social scientist I have learnt low throughput, medium and High. I have learnt some right terminologies in Food science and Breeding. Appreciate consumer acceptability in the lab.
The power of instrumentation measurement The evolving trait preferences for products The innovations in PVS
CATA JAR Setting the thresholds
1. Better way of interacting with breeders. 2. More knowledge on priority quality traits important to both breeders and food scientists as it pertains to consumer preferences. 3. High to medium throughout methods available and to be developed for rapid phenotyping of PQTs.
Quality traits prioritized and ranked for fufu product Texturometer settings
Image analysis Texture analysis Sensory analysis
Among many lessons learnt, Now i know about high throughput tools useful for key traits assessment like color, texture and dry matter I've learnt that only useful traits should be given priority of analysis Food quality of improved variety is critical to the adoption by the end users.
I've been exposed to another method of color analysis- image analysis I've been exposed to the use of another statistical tool- excel stat
Texturometer use NIRS data processing Possibility with image analysis Better insight on the outcome of the expected project
Use image to assess foods quality. Texture equipment calibration and protocol validations Food scientist and Breeders Collaboration
Common objectives between RTBfoods and AfricaYam
*Improved knowledge in the use of texture analyzer *The mode in which imaging spectra is carried out *How NIRS works
1. The possibility of correlating sensory data with textural data 2. How to generate threshold for traits 3. Better understanding of how to score traits during sensory evaluation
Application of imaging to color measurements Sensory profile Textural profile
1.The possibility of developing a model that can predict consumers acceptability of yam 2.The major traits in yam products 3.The importance of engaging with crop breeders in new product development
1. Improved upon use of descriptors 2. Sampling of tubers for analyses 3. Statistical tools for analysis of data from consumers acceptability test
The work of breeders The work of food scientists The need to incorporate the works of the two bodies

Cite 3 new things you've learned/ discovered during this training
Under sensory evaluation test, texture and mealiness is main key for assessment
Textural Sensory Physicochemical factors of quality
1. Ranking of the preferred quality traits from consumers perspective 2. Interaction with other partners in understanding the process of SOPs validations
I have learnt how to practically do texture and sensory analysis I have improved my knowledge on sensory data analysis using XLSTAT I have made interactions with product champions
The use of sensory evaluation and texture machine measurement to better explain traits that could be used by breeders Proper sample selection for representative sampling Networking opportunity with other scientists
1) Breeder and food scientist relationship is key during yam clone selection and adoption 2) End users (processors and consumers) of yam products are also key 3) Taste and color are great choices for the yam consumer
Methodological approach Data analysis Necessity for strong collaboration between breeders and food-technologists
1.) The use of the thresholds 2.) Image analyses, 3.) Hyperspectral Imaging to prediction the traits
i got to understand that quality is key in breeding I learnt that instrument and qualitative data could be correlate to develop high throughput methods
1. Standardized SOPs for boiled and pounded yam quality. 2. Bridging the gap between breeders and Food scientists for greater effectiveness. 3. Quality traits prioritization
1. Image assessment 2. Use of texturometer and 3. Stretchability not elasticity
Introduction to texture analysis Image analysis
Improve my level in the use of the texturometer Discipline at work through the different workshops The friendliness and atmosphere that prevailed throughout the training period

What specific points do you wish to apply in your daily activities?
SOP for sensory analysis
Image analysis Sensory evaluation optimization Sampling techniques
Samples preparation and sensory data collection
Talking more with my team members and conflict resolution
Total Participatory in all aspects of the task
I wish to Apply in my daily activities: - G+analysis in term of positive benefit and do not harm according to different selected traits on boiled yam,
The application of the new RTB techniques in pounded yam and boiled yam quality assessment, application of the quantitative data analysis in the analysis of sensory and textural activities with the new techniques in spectrum applications
image analysis NIRS application

What specific points do you wish to apply in your daily activities?
Data processing in image analyses
Group can be duplicated on consumer tests to decrease error range
The application of the texture analyzer to the sensory properties To achieve a good SOP
1) as a food Technologist I want to pay more attention to some " supposed to be" high throughput methods that I've been ignoring 2) work more on SOPS
1. Use of the standardized protocols 2. Image analysis of yam genotypes
Use the texture analyzer on plantain samples and other products; Apply QDA within the framework of the RTBfoods project following the development of the vocabulary;
ITPA and STPA validation Harmonizing SOPs How to use and measure other rheological properties apart from ITPA and penetrometry
Combining lab techniques of consumer testing trained panelists and consumer testing in the field
Tools that predict good qualities in early breeding cycle. Trait prioritization based on WP1 results
To focus on evaluation of predictors to PQTs for yam screening and quality evaluation
Wp5 Methodology on fufu product
Sensory testing
The use of textural analyzer to determine texture quality of boiled yam
Use of excel stat in data analysis
Texture, sensory, images
Apply textural methods on plantain product Apply sensory protocol on plantain product
Hyper spectral data management
- the characterization of boiled yam sampling and sample preparation for steaming of yam tubers for lab analyses - sensory analysis -Textural measurements -analysis sensory data
The improved knowledge in the use of texture analyzer and correlating the results with sensory evaluation data
1. Apply my new knowledge of how to score parameters during sensory evaluation during training of panelist so that they will have a better understanding of what is expected of them. 2. Operate my institute's texturometer better by applying the knowledge I have acquired in the course of this training.
Imaging analysis
Engage with relevant expertise in daily activities
The use of standardized SOP for consumer acceptability test
Incorporating food science aspects into breeding
Interactions with food scientists
Routine evaluation
Validation of the SOPs
Sensory and textural data analysis
Proper sample presentation and training of sensory panelist for sensory
As a good scientist, physicochemical properties of food crops must be well noted
Involving food scientists in the breeding activities from the beginning, and at each step until end
image chat and sensory method
Better tools for PVS and sensory analysis
Training & retraining panelist

What specific points do you wish to apply in your daily activities?
Texture analysis
Discipline at work

What would be the next steps to make it possible to apply this new knowledge in your daily work
further training upgrading of laboratory infrastructure
1. Sensory evaluation optimization = procurement of needed materials and implementation 2. Access and direct application of sop for most tools and procedures
Train panelist and validate their performance for repeatability
Organize a meeting to plan period 5 activities incorporating priorities traits for our different product profiles
Motivation and commitment are the key steps to apply this knowledge gained into our daily activities
I would like that the programme of RTBFOODS gender group reinforce our capacity on that. The second thing is to organize the training how to write the good scientific paper.
I had already contacted my colleagues in Nigeria to get ready we going to start our harvest and PVS assessment. Therefore, immediately am back I will teach them the new techniques, approach and system been learnt here so that we will have an effective result
Acquiring a NIRS more practical session on image analysis
It will be applied to cassava
Consumer tests on 15 hybrids on next Monday
To follow all that I learnt in the right way ND be effective in my laboratory analysis.
Get back home, think introspectively and do the next period's work plan
Liaise with my team to implement what we have learned in our breeding program
Develop a SoP for sample preparation; Understand the functioning of the texture analyzer and develop a SoP for use; Develop a SoP for sensory analysis.
Using the array of statistical tools learnt in analyzing sensory and textural analysis Analyzing other biophysical attributes associated with ITPA and STPA
Integration of multidisciplinary approach
Synergizing with social and food scientists.
Set a panel
1. Go over the presentations and SOPs again as uploaded on the RTBfoods page. 2. Practice every day the things I have learnt.
Collaborative action with NRCRI team on next cassava harvest session
Get the SOP and apply it
Availability of the tools to be used and quick accessibility of the result
Further training on excel stat and use of texture analyzer
Update workplan
Textural measurements
Develop HSI batch analysis using R and Python with Karima
The analysis of sensory data Textural measurements
Practicing, connecting with those who have successfully applied it (4)
1. Pass the knowledge to the rest of my team who didn't attend this training, so we all can be on the same page and work accordingly as a team 2. Take note of the essential quality traits pointed out and make them a priority. 3. Work on the proof of concepts so as to establish possible correlation between traits.
Have a meeting with the Breeders
I shall train my research team on the current sensory evaluation tools and skills

What would be the next steps to make it possible to apply this new knowledge in your daily work
Using it for the screening of genotypes
Having frequent interactions with food scientists and breeders
Combining aspects of breeding and food science
Acquisition and optimization of protocols
The next step is integrating the procedures for SOPS validation in our lab
Making sensory reports available
Constitute good sensory panel in my institution
Must always sensory evaluate food for its acceptance by consumers
Learning more data treatment and analysis to be able to translate accurately the information generated
establishment of an image lab
Reorientation and reorganization of project team for more effectiveness
Sensitizing coworkers & panelist to the improved approach
Training on available equipment in our Lab Acquisition of lacking equipment
1- Take stock of new knowledge 2- Integrate each of his knowledge into my daily life as needed 3- Assess if necessary the level of integration of this knowledge

If any theoretical sessions were not relevant for you explain why
NIRS and image analysis are complex and further training need
They were relevant
The theoretical session prepared me for the practical section
All were relevant
I find all the sessions relevant although the NIRS angle is not really relevant to me. The Textural sensory and imagining is highly important to me and of more valuable use than the NIRS
I need more document to complete my understanding.
Because some of them are already in our SOP guidelines and we have been practicing them but not in a detailed as was taught
Image and NIRS session was hard for me because I've never heard of it before
I didn't see any need of using the camera for imaging when the chromameter can easily give me the color spectrophotometrically
They were all relevant
They were relevant
Not perfectly familiar with the breeding process previously High throughput technique require an already reasonable level of theoretical knowledge
I appreciated all theories
Technical complexity of first exposure
NIRS session was so difficult to follows because of less of practical cases
The use of NIRS is not very clear at all
Sound too theoretical and not applicable
Too far from my daily activities
The use of imaging and NIRS are relevant needs more understanding to be able to use and interpret the data generated
All the sessions were relevant and insightful
They are very relevant
The technicalities were too much

All the sessions were interesting
They are relevant
Didn't really understand the breeding aspect as a food scientist
Because the dedicated was not enough
they were relevant
Maybe too specific

If any practical sessions were not relevant for you explain why
All practical sessions relevant
They were relevant
All practical sections were interesting
The practical sessions were very useful
We do mostly the imagining, Textural and sensory in my office
They were relevant but some are just newly introduced to us, so we are not quite conversant with it but with continue practice I think I will be expert on it
Everything is well done
NIRS and image was too high for my understanding
They were all relevant to me
Was very relevant
They were relevant
None. All were useful
Because of lack of practice, hardness of the software user for data analysis
The use of NIRS is not clear to me. Maybe the training will be more suitable for the food scientists
The NIRS is relevant, but found it not interesting
Some equipment is not available in my laboratory
The practical sessions were relevant, insightful and offers an opportunity for better and efficient output.
They are the most important part of the workshop
I cannot see myself applying that immediately
There was not enough time for hand-on practical
Time for practical too short
They are relevant
All the workshops were relevant only that the time allocated to them was short
They were all very relevant
Didn't really understand. Next time will learn more from website and research on them before coming
All I have learnt was relevant
the NIRS is not widely available
The ones I attended were very relevant
1. It was more of theory than practical. 2. The packages used are not accessible.

What were the main highlights of the Training?
breeders and food scientists to collaborate more effectively. SOP developed be deployed and adopted
Working together
There are a lot of benefits from stronger and sustained collaboration between breeders and food technologists which will aid greater and deeper impact on food security

What were the main highlights of the Training?
Breeders and food scientist need to work together to achieve the goal of RTBfoods.
Productivity can be enhanced if we have a good working relationship
The best way to predict the future is to create it. If I want something I have never had, I think I must be willing to do something you've never done. Some of these new lessons I have learnt I need to put them in practice for a better result
Continue to work to give a key trait to breeder according to gender Interdisciplinarity
My main highlights are on the principle guidelines on yam quality assessment and data collection from the panelists, interaction, exposure, experience and my understanding on the systems and application which will help me to develop and meet the main objective of this noble project
Food scientists and breeders should work more closely.
Tools and methods for evaluating yam quality
Breeder needs food scientist. They all need to work together
Acquiring HTTP to work with so as the breeders will get a better result
Holistic approach (all stakeholders: food scientist, breeders, sociologist, farmers) should be involved in breeding RTB crops that consumers want
1. It's possible to predict yam quality parameters 2. Improved sensory evaluation methods 3. Breeders need to be involved in yam quality assessment
Thank you for enabling this training for the young scientists that we are. I really appreciated the participation and its content. The ball is in our camp to correlate sensory data with QDA data and provide information to breeders
The necessity to align textural and sensorial properties The need for collaboration between breeders and food technologists
Ensuring interdisciplinary approach
My breeding approach will improve will more precise focus on quality management
Importance of setting a workflow by both breeders and food scientists from the beginning
Food quality parameters are important for evaluation so as to ensure consumer acceptability. This should be the major focal point for both breeders and food scientists
Main qualities traits of fufu well identified for raw, material, intermediate and final product
Key traits and their screening techniques
Breeders and food Scientists need to work together for better result
It is possible to predict properties of yam food product using instrumental method, once the method has been developed and validated. I found the use of Xcel stat for analysis to be user-friendly and could replace use of SPSS for my analysis
A joint work is paramount between breeders and food scientists 4 traits are essential to breeders (mealiness, stretchability, smoothness, hardness)
Foods quality prediction
Sharing practices is a good way to make fast progress and to be able to recognize other's work
reproduction and statistical analyzes
Data analysis
1. Food quality is of utmost importance in meeting end users need 2. There is possibility of a high throughput method that will enhance operations. 3. There is need for breeders and food scientists to work hand in hand for better productivity and end user satisfaction
The need for breeders to engage the Food scientist in their programmes. The Food scientists should also be willing to work with the breeders
Work closely with Food scientist in screening breeding lines
The need to incorporate aspects of food science into yam breeding
The need to include food scientists in breeding activities
The need to work as a team

What were the main highlights of the Training?
We need to show how the textural traits are related to the biophysical parameters
Breeders must work with food scientists Harmonization of vocabulary is key
Better approach to scientific measurement Better working relationship with my institutional breeders, particularly yam breeders
As a food scientist, I need to work harder and help breeders in lab proceedings
This training allows me as a plant breed to kwon the importance to have more interactions with the food scientists in order to achieve good results
my take home is that a high throughput method will be developed soon and this mean more work for the food scientist
That breeders and Food scientists should work together as a team.
Training of panelist is continuous
Interaction with partners Correlation between survey traits and lab analysis

Any complementary suggestions?
Training very good and informative. More time should be allocated for practical sessions in future Trainings.
The training was insightful and impactful for me
I am grateful for this opportunity that has enlightened me to sensory and quality data collection. The organizers were indeed competent and friendly.
This type of workshop should be organized periodically
Many thanks to the organizers of this program. Although the training workshop timing was too short. I suggest more timing for practical sessions; to ensure full participation of trainees for better involvement
I am very happy to be part of this training. I wish this initiative will continue through coaching sessions.
Yes, my regards to the entire team who made it possible for this epoch event to hold notwithstanding the unforeseen circumstances by coming all the way from your country to Africa just to make sure that there is food sustainability and improvement in food quality in Africa as a whole, I must commend the Bill Melinda gates foundation, Cirad, Africa yam, RTB and the host county for their resilience, efforts to make sure that life is comfortable for the common man and the entire human race. I equally wish to ask for the availability of all the materials for our personal consumption as this will enable us to work actively.
I really appreciate the workshop
This workshop should be done at the beginning of the program. Now we will correct errors done in the 1st period of the program
Hope for more trainings so that we can share knowledge easily and also scientists and breeders should share SOP so we can all work as a team.
The training WELL ORGANIZED!!!!! I appreciate all organizers. It was very thought provoking and insightful
I wish to appreciate the CIRAD for extending the invitation to me. I am most grateful
The program is overall well planned in spite of difficulties Great administration Great meals😉
A very good meeting, ensuring romance and final marriage between discipline
Nice social engagements in the course of training
A big thank you to RTBfoods PMU for organizing such a resourceful workshop for us. THANK YOU!
Great workshop and interaction with participants. It is well organized and happy with it
Its been a wonderful workshop for me. I really appreciate the data analysis aspect. Thank you for this wonderful training

Any complementary suggestions?
I found the training session very enlightening and educative. I wish it could be extended for better hands-on experience
Great meetings. But more time was need for the practice. Congratulations and gratitude to all the organization team
Many practice
More practical exercises should have been really interesting. Congrats to organizers.!
I would like to thank the Africa Yam project and RTB foods for this enriching training which allowed me to meet other people from other institutions and to bring me more knowledge on the quality of yam.
It's an insightful and interactive workshop. However, it will really be great to have all labs interact beyond the use of developed SoPs from a distance.
Thanks to RTBfoods and Africa Yam for such an amazing opportunity
The training was well organized.
Organize another workshop possibly
The time of the hand-on practical work has to increase
The program was more educative
Wellington planned and organized training workshop
All the trainers are very friendly. I love their approach of teaching and interactions. Johnson did a wonderful reporting work. Dominic was wonderful in coordinating Cathy and our meeting coordinator worked so hard Feeding was excellent Thanks for everything. Looking forward to more feature interaction
Training was satisfactory. More time needed for lab practical
Just to thank RTBfoods and all partners for giving me this great meaning opportunity. I hope there will be another to do more practices
The training a wonderful one ..I leant a lot and i appreciate the organizers
The workshop was very rich, educative and well organized
Great workshop, good organization & coordination. More time need to be a located for trainings as this.
Very good Workshop... If possible, to be reprogrammed for another crop (cassava, potato, etc.)

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