Scientific Report

High-Throughput Phenotyping Protocols – RTBfoods Scientific Achievements Report from Period 1 to 5 (Nov. 2017-Jan. 2023)

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

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ABSTRACT

This scientific report shows the contributions of all the teams (NRCRI, NaCRRI, IITA, CIP, CIRAD, INRAe, NARL) involved in work package 3 to develop HTP and MTP methods as part of the RTBfoods project for 5 years from 2018 to 2023.

The report describes all the main results obtained. the report details all the deliverables developed throughout the project. Indeed, the report highlights the achievements so far by product profiles: boiled cassava, Gari/Eba, Fufu, boiled and pounded yam, Matooke, boiled sweetpotato and boiled potato.

The presentation of the results is made with regard to the expected outputs, thus the different SOPs developed by product and by type of measurement and the different calibrations developed or in development are presented per product profile and detailed for their performances.

Advances on ontology for both physico-chemical and spectral data are summarized and bottlenecks are identified and commented. The progress of data transfers to BreedBase is drawn up.

The coordination activity of WP3 is described and commented especially regarding the strategy for capacity strengthening of partners (trainings and supports, acquisition of equipment) and the scientific support to the teams (masterclass, webinars, state of knowledge, sharing R scripts, co-development of calibration…).

A particular discussion is done concerning the interactions with the other work packages.

The last part of this report focuses on the lessons learnt and their consequences.

The scientific report ends with the remaining challenges and with the key priority actions to be taken for the next phase. These actions are broken down into activity programming by product and by institute.

Key Words: NIRS, HSI, Imaging, High throughput, roots, tubers, texture, quality traits

1 PRODUCT PROFILES & WP3 TEAMS ACROSS COUNTRIES

Crop	Product Profile	Product Champion	Partner Institutes responsible for WP3 activities	WP3 Team Composition	
				Product Profile WP3 Correspondent	Names of other Operational Staff for WP3 Analyses & Data Management
Cassava	PP1- Boiled Cassava	Robert Kawuki (NaCRRI-Uganda)	NaCRRI-Uganda	Ephraim Nuwamanya	Babirye Fatumah Namakula, Enoch Wembabazi
			CIAT-Colombia	Thierry Tran	Thierry Tran, Luis Londoño, John Belalcazar
			CIRAD-Montpellier	Karima Meghar	Karima Meghar
	PP2- Gari, Eba, Attiéké	Busie Maziya-Dixon (IITA-Nigeria)	IITA-Nigeria [Gari/Eba]	Emmanuel Alamu	Michael Adesokan, Hakeem Oyedele
			NRCRI-Nigeria [Gari/Eba]	Ugo Chijioke	Ernest Ogbete Chukwudi
	PP3- Fufu	Ugo Chijioke (NRCRI-Nigeria)	NRCRI-Nigeria	Ugo Chijioke	Ernest Ogbete Chukwudi
Cooking Banana	PP5-Matooke	Kephas Nowakunda (NARL-Uganda)	NaCRRI/NARL/IITA-Uganda	Ephraim Nuwamanya	Enoch Wembabazi
			IITA	Brigitte Uwimana	Ephraim Nuwamanya
Sweet potato	PP7- Boiled SP	Reuben Ssali (CIP-Uganda)	CIP-Uganda	Judith Nantongo	Judith Nantongo Edwin Serunkuma
Yam	PP9- Boiled Yam	Noel Akissoe (UAC-FSA-Benin)	IITA-Nigeria	Emmanuel Alamu	Michael Adesokan, Hakeem Oyedele
			NRCRI-Nigeria	Ugo Chijioke	Ernest Ogbete Chukwudi
			INRAe Guadeloupe	Lucienne Desfontaines	Lucienne Desfontaines
			CIRAD-Montpellier	Karima Meghar	Karima Meghar
	PP10-Pounded Yam	Bolanle Otegbayo (Bowen University-Nigeria)	NRCRI-Nigeria	Ugo Chijioke	Ernest Ogbete Chukwudi
			CIRAD-Guadeloupe	Cornet Denis	Cornet Denis
Potato	PP11-Boiled Potato	Thiago Mendes (CIP-Kenya)	CIP-Uganda	Judith Nantongo	Judith Nantongo Edwin Serunkuma

2 WP3 CONTRIBUTION TO PROJECT OUTPUTS

2.1 WP3 summary narrative

The WP3 of RTBfoods project consists of eight teams from different institutes (INRAe, CIAT, CIP, IITA, NACRRI, NARL, NRCRI and CIRAD) over seven countries (Uganda, Nigeria, Colombia, Peru, Guadeloupe, Ghana and France). The aim of WP3 is to develop high throughput phenotyping protocols (mainly NIRS) that can be applied in national and international breeding programs, postharvest processing and quality control procedures. WP3 has been coordinated by **IITA** (E. Alamu), **CIRAD** (F. Davrieux, K. Meghar and D. Cornet) and **CIP** (T. zum Felde). The work of WP3 aimed to make a strong contribution to the following outputs: Output 5: “Standardized ontology established for major quality traits and spectral databases developed for food quality traits”, Output 6: “Screening capacity for users’ preferred quality traits developed in key countries” and Output 7: “Operational HTP (or MTP) protocols platform for screening users’ preferred quality traits developed”.

From the beginning of the project, the states of knowledge regarding the use of spectral methods and hyper spectral imaging for the characterization of tubers and roots have been drawn. The conclusions of this first work made it possible to collectively define the work priorities, the actions to be carried out within each institute, the pooling of instruments and the investments to be favored. At the beginning of the project 14 NIR spectrometers were available and, except NARL in Uganda, each team owns a least one NIR spectrometer. Over the project period, 3 HTP tools were purchased: 2 hyperspectral cameras (CIRAD, France and IITA, Nigeria) and one benchtop NIRS (CIAT). In addition, the RTBfoods Project has co-funded 2 portable instruments (QualitySpec, ASD), one at CIAT with co-funding from NextGen and one at CIRAD Agap with co-funding from CIRAD.

From the first year of the project, efforts have been made to train WP3 teams with training in vibrational spectrometry theory, multivariate data analysis, chemometrics, calibration and in the use of software (Winisi and Unscrambler). At the end of project 14 training sessions were achieved, these sessions were either face-to-face or online (webinars and masterclass). More than 60 partners were thus able to obtain theoretical and practical support for the development of high-throughput phenotyping methods using vibrational spectroscopy.

During the project more than 22,660 spectra were acquired for cassava (12,873), yam (4,378), banana (1,478), sweet potato (3,152) and potato (780). These acquisitions were made for different presentations of the roots and tubers: from fresh intact to dried flour, passing through fresh ground or grated. Some of the acquisition were done on processed product such as fufu, gari, boiled cassava and cooked sweetpotato. in fact, the number of spectra acquired is slightly lower than expected due to the COVID crisis which disrupted access to the fields during harvesting and sampling campaigns. To these spectral data are added images acquired by HSI, CCD digital camera, and DigiEye system (VeriVide, Leicester, UK).

To carry out these measurements, operational procedures have been established and then standardized (SOP). These procedures have been written and made available online for all types of products and instruments used by WP3 researchers. In total 21 SOPs for 7 product profiles (boiled cassava, fufu, Gari-Eba, boiled potato, boiled sweetpotato, boiled Yam and matooke) were developed. These SOPs concern NIRS, MIRS, imaging and HSI measurements using benchtops instruments (FOSS DS2500, FOSS XDS, camera SPECIM FX17 and DigiEye) and portable instruments (ASD QualitySpec and ASD LabSpec). The spectral data, the physico-chemical and/or sensory data as well as the information relating to the samples are all recorded by institute/product/presentation in standardized files in Excel© format. These files also contain the characteristics and performances of the calibrations when these are available. All databases are available on the RTBfoods platform (https://rtbfoods.cirad.fr/).

For this project seven institutes (CIRAD, IITA, CIAT, NRCRI, NaCRRI, CIP and INRAe) worked on 5 crops (banana, cassava, yam, sweetpotato and potato) for 8 product profiles (boiled cassava, fufu, Gari-Eba, boiled potato, boiled sweetpotato, boiled Yam, pounded yam and matooke). For output-7, they developed different calibrations for 51 quality traits using NIRS, MIRS, imaging and HSI.

Calibrations were based on measurements done on 16 different presentations (boiled yam, cooked freeze-dried milled, cooked intact, cooked mashed, dried ground, eba, Fresh grated, fresh ground, fresh intact, fufu flour, milled gari, raw freeze-dried milled, raw intact, raw mashed, unmilled gari and wet mashed fufu).

The main results confirm that spectral tools are perfectly suited for the measurement of biochemical parameters (DM, amylose, starch, protein, sugars...) when applied to homogeneous material, such as flour. However, calibrations developed from fresh material, just ground or grated, present performances that are entirely compatible with an application to high-throughput phenotyping. As an example, the quantification of amylose content (expressed as % of Starch) in fresh cassava samples developed by NaCRRI (Uganda) presents high performances with and R^2 of 0,94 and prediction error SEP = 1,02%.

But the studies done for direct characterization of roots and tubers texture using spectral fingerprint measured on fresh material have been inconclusive, whether on the basis of parameters quantified by physical measurements (texturometer) or by sensory evaluation (panel of tasters).

For this, approaches using image analysis (DigiEye, CCD digital camera) have shown that it is possible to link the image of a root or tuber section to texture parameters and color before and after transformation (cooking or pounding). So, CIRAD and INRAe (Guadeloupe) applied, with success, imaging (digital CCD camera) on fresh Yam samples for the characterization of Yam discoloration. For this, they defined a browning index directly calculated from the extracted colors from the images. And the CIP in collaboration with the COCIS (Makerere, University) in Uganda carried out with promising results the characterization of the color and mealiness of sweet potatoes, both evaluated by a panel of tasters. To do this, the images (DigiEye) of roots (whole and/or cut) were associated with the scores of the panel and effective models were developed for the prediction of the intensity of the orange color and the characterization of mealiness-by- hand.

Furthermore, the application of hyperspectral imaging, which combines these two approaches: spectral and image, has demonstrated potential for characterizing the processing ability of tubers and roots. Indeed, the possibility of being able to draw up a cartography of the spatial distribution of the different constituents in the root makes it possible to imagine the calculation of a homogeneity index which itself would be linked to the aptitude for transformation.

Classification approaches based on spectral fingerprints and consumer-defined classes have demonstrated strong potential for the selection of genotypes of interest. It was thus demonstrated in a joint CIAT-CIRAD (Colombia, France) study that the spectral fingerprint, taken from grounded fresh cassava tubers, made it possible to correctly classify genotypes (classification rate in prediction = 81,4%) according to their ability to absorb water after 30 minutes of cooking. CIAT has demonstrated the strong relationship between cooking time and the ability to absorb water. Similarly, a study conducted by IITA (Nigeria) and CIRAD (France) demonstrated the interest of combining spectral analysis and deep learning tools (convolutional neural network) for the classification of yam genotypes, the classes (poor or good) being defined by the breeders according to the poundability. the results obtained showed classification rates, in validation, of 91,7%.

The classification approach based on spectral or image data should be pursued based on acceptability thresholds defined by consumers and formalized by WP2 researchers.

This project has enabled teams of researchers in different institutes to develop the skills for an autonomous use of vibrational spectroscopy, and the ability to integrate it into their own research and development projects. Moreover, several collaborations between the teams were initiated during the project and have become sustainable. The collaboration between the IITA and the NRCRI in Nigeria, with scientific support, sharing of SOPs, reception of researchers and the provision of spectrometers is a good example. Like, the collaboration between NaCRRI, IITA and CIP in Uganda which has resulted in jointly developed SOPs, shared resources and sustainable scientific and technical support. Just as the joint calibration development between CIAT and CIRAD was a success.

The remaining scientific & technical challenges to be overcome within the next 2 years are:

- Effort on the rigor of the implementation of the analytical chain: sampling - physico-chemical & sensory measurement - spectral measurements - modeling - external validation.

- Increase robustness of current NIRS models using external validation and continuous model enrichment.
- Capacity enhancement on equipment maintenance Support for the use of free and open source software, exchange of scripts.
- Use future acceptability thresholds (from WP2) to calibrate dedicated classification models using NIRS.
- strengthen proof of concept for the characterization of quality traits from measurements on fresh products.
- Application of hyperspectral imaging for the characterization of the spatial distributions of constituents (homogeneity) within roots and tubers. Study of the relationships between levels of homogeneity and physical properties and aptitude for transformation.
- Developing specific scripts for data management, calibration development, image analysis…, using a common language.
- Thinking the best solution for images and HSI images storage and sharing.
- Creating web interface for deep learning/PLS models to share and apply the models in routine analysis.

2.2 Level of achievement of project targets

2.2.1 Project Target Indicator for Output 5

Commitment A: “*cassava: 15 000, sweetpotato: 2 500, yam: 500, potato: 1 500, banana: 1 000”*

Level of Achievement at the end of the 5 years:

The total number of spectra acquired over the period is by product: Cassava (12 873), Yam (4 378), Banana (1478), Sweetpotato (3152) and Potato (780).

If any difference between ‘Committed’ and ‘Achieved’: Explanation

The number of spectra acquired by product corresponds more or less to the initial figures. Regarding cassava and potato, the number of spectra is lower mainly due to 1) the COVID period, which impacted the harvest (cassava and potato), and 2) instrumental breakdowns (cassava). The important number of spectra for yam is probably due to an underestimation of the activities from IITA (Nigeria) and INRAe (Guadeloupe).

2.2.2 Project Target Indicator for Output 6

Commitment B: *“5 HTP tools (instruments) installed in key countries & 20 trainings on HTP tools & protocols to partner laboratories”*

Level of Achievement at the end of the 5 years:

- Over the period, 3 HTP tools were purchased: 2 hyperspectral cameras (CIRAD, France and IITA, Nigeria) and one benchtop NIRS (CIAT). In addition, the RTBfoods Project has co-funded 2 portable instruments (QualitySpec, ASD), one at CIAT with co-funding from NextGen and one at CIRAD Agap with co-funding from CIRAD.
- 14 training sessions were achieved: P1 (5), P2 (2), P3 (0), P4 (4), P5 (3).

If any difference between ‘Committed’ and ‘Achieved’: Explanation

- Five instruments were planned when the project was written, but the equipment already in place in the various institutes were sufficient to cover the analytical needs. Therefore, a choice was made to limit investments to invest in new technologies (HSI). In addition, a part of the investment sources has been mobilized to strengthen the analytical capacities of WP2.
- 6 planned training sessions were not carried out. This corresponds to 4 sessions scheduled in period 3 which were cancelled due to the COVID crisis and to 2 sessions which were gathered within 2 larger sessions in Period 2 for reasons of economy (travel) and for greater efficiency.

2.2.3 Project Target Indicator for Output 7

Commitment C: *"14 HTP or MTP SOPs adapted and developed & 22 calibrations for major prioritised quality traits developed for 11 RTB food products & accessible to RTBfoods partners on RTBfoods secured platform"*

Level of Achievement at the end of the 5 years:

- **6 institutes** (CIRAD, IITA, CIAT, NRCRI, NaCRRI and CIP) worked on **5 crops** (banana, cassava, yam, sweetpotato and potato) and developed **21 SOPs** for **7 product profiles** (boiled cassava, fufu,Gari-Eba, boiled potato, boiled sweetpotato, boiled Yam and matooke). These SOPs concern NIRS, MIRS, imaging and HSI measurements using benchtops instruments (FOSS DS2500, FOSS XDS, camera SPECIM FX17 and DigiEye) and portable instruments (ASD QualitySpec and ASD LabSpec).

- **7 institutes** (CIRAD, IITA, CIAT, NRCRI, NaCRRI, CIP and INRAe) worked on **5 crops** (banana, cassava, yam, sweetpotato and potato) for **8 product profiles** (boiled cassava, fufu, Gari-Eba, boiled potato, boiled sweetpotato, boiled Yam, pounded yam and matooke). They developed **calibrations for 51 quality traits** using NIRS, MIRS, imaging and HIS Calibrations were based on measurements done on **16 different presentation**s (boiled yam, cooked freeze-dried milled, cooked intact, cooked mashed, dried ground, eba, Fresh grated, fresh ground, fresh intact, fufu flour, milled gari, raw freeze-dried milled, raw intact, raw mashed, unmilled gari and wet mashed fufu)

3 WP3 MAJOR SCIENTIFIC ACHIEVEMENTS OVER THE LAST 5 YEARS

3.1 Development of standardized operating procedures (SOPs) for NIRS, MIRS & imaging on RTBs

The coordination team of WP3 was involved in the development of SOPs. A template for SOPs was firstly predefined and then an efficient process has been implemented, for reviewing and validating SOPs provided by RTBfoods partners. This process consists of the following steps:

1. Collect SOPs from partners
2. Submission of the SOP in the format of a predefined template.
3. First review by K.Meghar of the SOP and ask for correction if needed.
4. Second review and final validation by E. Alamu and F.Davrieux.
5. Formatting and uploading on the RTBfoods platform by The PMU team.

Over the five years, the coordination team reviewed and validated 21 SOPs: 11 SOPs for NIRS measurements, 6 SOPs for imaging, 2 for hyperspectral imaging measurements, 1 for MIRS measurements and 1 for color measurements using a chromameter. During this process, we faced the following challenges: The similarities of some SOPs from different institutes referred to the same instrument for the characterisation of the same product. That is why the coordination team decided to harmonise the SOPs, which refer to similar products/presentations.

Fill-in the summary Table of SOPs developed over the last 5 years:

Partner Laboratory	Country	SOP Title + DOI	Device	RTB crop concerned					Product Presentation
				Cassava	Cooking banana	Potato and Sweet potato	Yam	Banana	
IITA	**Nigeria**	Harmonised SOP for NIRS measurement on intact cassava roots and yam tubers using NIRS FOSS : (https://doi.org/10.18167/agritrop/00665)	FOSS XDS	X			x		Pieces of fresh root and tuber
NRCRI	**Nigeria**	Harmonized SOP for NIRS acquisition on fresh intact and mashed cassava roots using portable NIRS ASD (https://doi.org/10.18167/agritrop/00678)	ASD QualitySpec	X					Fresh intact and mashed
NaCCRI	**Uganda**	NIRS acquisition on fresh cassava roots using the ASD Quality Spec (QST) and relating spectra to root dry matter content by oven(https://doi.org/10.18167/agritrop/00668)	ASD QualitySpec	X					Fresh intact
CIRAD	**France**	Feasability of bad-good genotypes screening using NIRS (https://doi.org/10.18167/agritrop/00671)	All	X	x	x	x	x	Fresh intact and mashed
NaCCRI	**Uganda**	NIRS acquisition on fresh cassava roots using the benchtop NIRS FOSS DS2500 and relating spectra to root dry matter content by oven method (https://doi.org/10.18167/agritrop/00669)	FOSS DS2500	X					Fresh intact
IITA	**Nigeria**	NIRS measurement on milled and un-milled Gari (https://doi.org/10.18167/agritrop/00674)	FOSS XDS	X					Milled and un-milled
CIAT	**Colombia**	SOP for NIRS measurement on fresh ground cassava (https://doi.org/10.18167/agritrop/00676)	FOSS DS2500	X					Ground
NRCRI	**Nigeria**	Determination of dry matter content of wet fufu mash using handheld NIRS (https://doi.org/10.18167/agritrop/00677)	ASD QualitySpec	x					Wet FUFU
NaCCRI	**Uganda**	for NIRS acquisition on fresh Matooke fingers using the benchtop NIRS FOSS DS2500 and relating spectra to finger dry matter content by oven method (https://doi.org/10.18167/agritrop/00679)	FOSS DS2500					x	Fresh intact

Partner Laboratory	Country	SOP Title + DOI	Device	RTB crop concerned					Product Presentation
				Cassava	Cooking banana	Potato and Sweet potato	Yam	Banana	
IITA	**Nigeria**	Harmonized SOP for NIRS Measurement on Blended Cassava and Yam using NIRS FOSS (https://doi.org/10.18167/agritrop/00706)	FOSS XDS	x			x		Fresh blended
CIP	**Uganda**	Near infrared spectroscopy (NIRS) acquisition on sweetpotato roots and potato tubers (https://doi.org/10.18167/agritrop/00708)	FOSS XDS			x			Fresh slices
CIRAD	**France**	Color measurements of RTB foods using image analysis (https://doi.org/10.18167/agritrop/00663)	Numeric camera	x	x	x	x	x	Fresh intact
CIRAD	**France**	for characterization of RTB starch grain size and shape through Imaging (https://doi.org/10.18167/agritrop/00670)	Numeric camera	x	x	x	x	x	Starch grain
CIRAD	**France**	characterization of RTB product colour change during time (https://doi.org/10.18167/agritrop/00672)	Numeric camera	x	x	x	x	x	Fresh intact
CIP	**Uganda**	Image capture in sweetpotato and potato, and sensory attribute prediction https://doi.org/10.18167/agritrop/00721	Digieye			x			Fresh intact
CIP	**Uganda**	DigiEye Calibration (https://doi.org/10.18167/agritrop/00722)	Digieye			x			Fresh intact
CIRAD	**France**	Creation of a color reference chart for RTB foods colour characterization (https://doi.org/10.18167/agritrop/00673)	Numeric camera	x	x	x	x	x	Fresh intact
CIRAD	**France**	Operating mode and parameters configuration of hyperspectral camera Specim FX17 (https://doi.org/10.18167/agritrop/00667)	SPECIM FX17	x	x	x	x	x	None
CIRAD	**France**	SOP for hyperspectral imaging analysis of fresh RTB crops (https://doi.org/10.18167/agritrop/00666)	SPECIM FX17	x	x	x	x	x	Fresh intact
IITA	**Nigeria**	measurement in fresh yam (Dioscorea Sp.) and fresh cassava (Manhot esculenta) using chromameter (https://doi.org/10.18167/agritrop/00664)	Chromamater	x			x		Fresh intact

3.2 Development of prediction models for users' preferred quality traits per product profile

3.2.1 Product Profile: Boiled Cassava

- CIAT, Columbia, has developed **3 calibrations** on fresh ground cassava for OCT, DM and WA30 using NIRS. The respective number of samples used were 250, 250 and 2905. The calibrations performances are for OCT 72% of correct classification rate (2 classes), for DM R^2 = 0.95 and SEP = 0.97 and for WA30 the classification rate was 81,4% (2 classes).
- CIAT, Colombia, and CIRAD, France, have developed **2 calibrations**, on fresh intact and cooked intact cassava for DM quantification using HSI. The respective number of samples used were 116 and 100. The calibrations performances are for fresh R^2 = 0.94 and SEP = 0.96 and for cooked R^2 = 0.91 and SEP = 1.06.
- NaCRRI, Uganda, has developed **3 calibrations** on fresh grated cassava for DM, Amylose (as % of starch) and root softness using NIRS. The respective number of samples used were 300, 247 and 100. The calibrations performances are for DM R^2 = 0.99 and SEP = 0.81, for amylose (as % of starch) R^2 = 0.94 and SEP = 1.02, and for root softness R^2 = 0.37 and SEP = 2.44.

3.2.2 Product profile: Gari-Eba

- IITA, Nigeria, has developed **2 calibrations** on fresh intact cassava for starch and DM quantification using NIRS. The respective number of samples used were 208, 240. The calibrations performances are for starch R^2 = 0.79 and SEP = 2.37 and for DM R^2 = 0.77 and SEP = 1.42
- IITA, Nigeria, has developed **2 calibrations** on fresh intact cassava for starch and DM quantification using NIRS. The respective number of samples used were 208, 240. The calibrations performances are for starch R^2 = 0.79 and SEP = 2.37 and for DM R^2 = 0.77 and SEP = 1.42
- IITA, Nigeria, has developed **2 calibrations** on fresh ground cassava for starch and DM quantification using NIRS. The respective number of samples used were 52, 130. The calibrations performances are for starch R^2 = 0.73 and SEP = 5.21 and for DM R^2 = 0.94 and SEP = 1.5
- IITA, Nigeria, has developed **8 calibrations** on dried ground cassava for Ash, Amylose, Starch, Sugar, Protein, Fat, Ash and Moisture quantification using NIRS. The number of samples used was 260 for all parameters. The R^2 for calibrations are respectively: 0.93, 0.16, 0.15, 0.07, 0.73, 0.12, 0.89, 0.81 and the SEP are respectively: 0.26, 1.51, 2.23, 0.729, 0.391, 0.296, 0.263, 3.11
- IITA, Nigeria, has developed **5 calibrations** on Eba samples for Chewiness, Gumminess, Adhesiveness, Cohesiveness and hardness quantification using NIRS. The number of samples used was 40 for all parameters. The R^2 for calibrations are respectively: 0.48, 0.21, 0.33, 0.94 and 0.79 and the SEP are respectively: 48.06, 54.66, 67.72, 0.2 and 40.73.
- IITA, Nigeria, has developed **10 calibrations** on Un-milled Gari samples for Amylose, Starch, Sugar, Solubility, swelling power, Ash, Moisture, Dispersibility, Bulk Density and Water Absorption quantification using NIRS. The number of samples used was 48 for 7 first parameters and equal to 129 for Dispersibility, Bulk Density and Water Absorption. The R^2 for calibrations are respectively: 0.35, 0.12, 0.12, 0.62, 0.95, 0.41, 0.79, 0.12, 0.38 and 0.58 and the SEP are respectively: 2.55, 0.86, 0.49, 2.50, 1.35, 0.14, 1.19, 6.05, 0.04 and 64.79.
- IITA, Nigeria, has developed **3 calibrations** on milled Gari samples for the quantification of Dispersibility, Bulk Density and Water Absorption using NIRS. The number of samples used was 129 for all parameters. The R^2 for calibrations are: 0.53, 0.01 and 0.53 and the SEP are: 5.59, 0.05 and 50.89.

3.2.3 Product profile: Fufu

- NRCRI, Nigeria, has developed **2 calibrations** on fresh intact cassava samples for starch yield and DM quantification using NIRS. The number of samples used was 175 for starch yield and 98 for DM. The R^2 for calibrations are 0.68 and 0.85 and the SEP are respectively: 2.70 and 2.39.
- NRCRI, Nigeria, has developed **6 calibrations** on dried ground cassava samples for moisture, crude fibre, sugar, starch, amylopectin and amylose quantification using NIRS. The number of samples used was 21 for moisture and 50 for other traits. The R^2 for calibrations are respectively: 0.68, 0.80, 0.19, 0.71, 0.49 and 0.49 and the SEP are respectively: 1.94, 0.40, 0.96, 9.62, 4.39 and 4.39.
- NRCRI, Nigeria, has developed **5 calibrations** on fufu flour samples for solubility, swelling, power, amylose, pH and DM quantification using NIRS. The number of samples used was 40 for swelling, power, amylose, 42 for pH and 41 for DM. The R^2 for calibrations are respectively: 0.75, 0.56, 0.96, 0.55 and 0.79 and the SEP are respectively: 0.70, 1.16, 4.00, 0.47, 6.57.
- NRCRI, Nigeria, has developed **1 calibration** on wet mashed fufu samples for DM quantification using NIRS. The number of samples used was 60. The R^2 for calibrations is 0.65, and the SEP is 4.10.

3.2.4 Product profile: Boiled Yam

- IITA, Nigeria, has developed **1 calibration** on fresh intact yam samples for DM quantification using NIRS. The number of samples used was 400. The calibrations performances are R^2 = 0.95 and SEP = 3.13.
- IITA, Nigeria, has developed **5 calibrations** on fresh ground yam samples for Hardness, OCT, Water Absorption, Starch and DM quantification using NIRS. The respective number of samples used were 316 for the 3 first traits and 128 for starch and DM. The R^2 for calibrations are respectively: 0.21, 0.23, 0.23, 0.74 and 0.93 and the SEP are respectively: 224, 1.96, 0.83, 3.05 and 2.20.
- IITA, Nigeria, has developed **1 calibration** on boiled yam samples for hardness quantification using NIRS. The number of samples used was 90. The calibrations performances are R^2 = 0.97 and SEP = 182.
- CIRAD, Guadeloupe, has developed **1 calibration** on fresh intact yam samples for DM quantification using NIRS. The number of samples used was 2150. The calibrations performances are R^2 = 0.63 and SEP = 2.49.
- CIRAD, France, has developed **4 calibrations** on fresh intact yam samples for Hardness, starch, pectin and DM quantification using HSI. The respective number of samples used were 152, 108, 108 and 154 for hardness, starch, pectin and DM. The R^2 for calibrations are respectively: 0.47, 0.61, 0.82 and 0.99 and the SEP are respectively: 3.40, 9.20, 316 and 6.70.

3.2.5 Product profile: Pounded Yam

- INRAe and CIRAD Guadeloupe have developed **9 calibrations** on dried ground yam samples for sugar, starch, protein, DM, extensibility, springiness, adhesiveness, cohesiveness and hardness quantification using NIRS. The respective number of samples used were respectively 516 for the 3 first traits and 174 for the remaining traits. The R^2 for calibrations are: 0.997, 0.982, 0.991, 0.367, 0.513, 0.335, 0.508, 0.445 and 0.679 DM (0.79), extensibility (0.37), springiness (0.41), adhesiveness (0.34), cohesiveness (0.23) and harness (0.73) and the SEP are respectively: 0.98, 1.86, 0.75, 0.24, 0.17, 2.46, 0.11, 2.28 and 2.30 DM(1.58), extensibility (0.8), springiness (0.19), adhesiveness (2.22), cohesiveness (0.11) and harness (0.58). (Ehounou *et al*., 2021).
- CIRAD and INRAe Guadeloupe have developed **4 calibrations** on dried ground yam samples for cohesiveness, hardness, springiness and mouldability classification using NIRS.

The number of samples used was 174. The accuracies are respectively: 95, 55, 100 and 80%.

- IITA, Nigeria, has developed **1 calibration** on fresh ground yam samples for luminance quantification using NIRS. The number of samples used was 394. The calibrations performances are $R^2 = 0.83$ and SEP = 1.31.
- IITA, Nigeria and CIRAD, France have developed **1 calibration** on fresh ground yam samples for poor and good cooking time genotype classification using NIRS. The number of samples used was 200. The classification rate was 98%.

3.2.6 Product profile: Matooke

- IITA, Uganda and NaCRRI, Uganda and NARL, Uganda, have developed **1 calibration** on fresh ground banana samples texture and color quantification using NIRS. The calibration is under work.

3.2.7 Product profile: Boiled Sweetpotato

- CIP, Uganda, has developed **2 calibrations** on fresh intact sweetpotato samples for color and meliness quantification using DigiEye. The number of samples used was 360. The R^2 for calibrations are: 0.92 and 0.72 and the SEP are r: 0.58 and 2.21 for color and mealiness
- CIP, Uganda, has developed **1 calibration** on cooked intact sweetpotato samples for sensorial profile
- CIP, Uganda, has developed **1 calibration** on fresh freeze-dried sweetpotato samples for sensorial profile characterization using nirs. The number of samples used was 102. The calibration is under work. characterization using DigiEye. The number of samples used was 360. The calibration is under work.
- CIP, Uganda, has developed **26 calibrations** on fresh intact sweetpotato samples for DM, Starch, Amylose in starch, Amylose, Fructose, Glucose, Saccharose, Solubility, Swelling power, Pasting time, Pasting temperature, Peak viscosity, Trough, Final viscosity, Breakdown, Setback, Pasting time, Pasting temperature, Peak viscosity, Trough, Final viscosity, Breakdown, Setback, OCT, Firmness and Toughness quantification using nirs. The number of samples used was 225 for all traits except for OCT, Firmness and Toughness, for which n = 183. The R^2 for calibrations are respectively: 0.86, 0.60, 0.23, 0.35, 0.56,0.39, 0.91, 0.77, 0.84, 0.82, 0.79, 0.79, 0.79, 0.89, 0.07, 0.83, 0.80, 0.74, 0.70, 0.79, 0.80, 0.30, 0.82, 0.30, 0.07, 0.12 and the SEP are respectively: 1.42, 2.25, 2.15, 0.79, 1.25, 1.68, 3.87, 0.57, 0.35, 0.19, 1.29, 129, 136, 148, 51, 67.6, 0.17, 1.04, 64.6, 38.2, 54.6, 19.5, 18.5, 5.02, 590 and 1428.
- CIP, Uganda, has developed **1 calibration** on fresh intact sweetpotato samples for sensorial profile characterization using nirs. The number of samples used was 2359. The calibration is under work.
- CIP, Uganda, has developed **1 calibration** on fresh mashed sweetpotato samples for sensorial profile characterization using nirs. The number of samples used was 1043. The calibration is under work.
-
- CIP, Uganda, has developed **1 calibration** on cooked mashed sweetpotato samples for sensorial profile characterization using nirs. The number of samples used was 2023. The calibration is under work.
- CIP, Uganda, has developed **1 calibration** on cooked freeze-dried sweetpotato samples for sensorial profile characterization using nirs. The number of samples used was 69. The calibration is under work.

3.2.8 Product profile: Boiled Potato

- CIP, Uganda, has developed **1 calibration** on fresh intact potato samples for sensorial profile characterization using nirs. The number of samples used was 390. The calibration is under work.
- CIP, Uganda, has developed **1 calibration** on cooked intact potato samples for sensorial profile characterization using nirs. The number of samples used was 390. The calibration is under work.

Success Story Box n°1: The model developed for classification of cassava genotypes according to their ability to cook (cooking time) is extremely promising with a classification rate of 81%. This success is based on a large sampling of 2905 samples over 4 years and on a close collaboration between WP2 and WP3, and between CIRAD (France) and CIAT (Colombia). The demonstration made by WP2 of the importance of water absorption as well as the mastery of its measurement have made it possible to develop within WP3 effective classification methods from spectral data obtained on fresh cassava.

Success Story Box n°2: The calibrations, developed by NaCRRI (Uganda), for quantification of amylose (% of starch) and dry matter directly from spectra of fresh grated cassava is a success. The performances are excellent with R^2 = 0.94 and SEP of 1,02 % for amylose and 0,81% for DM. this success is due to a targeted sampling (300 samples) that covers the range of amylose and dry matter contents. In addition, revised analytical procedures and perfect coordination between WP2 and WP3 have enabled this success.

Summary Table of Calibrations initiated over the last 5 years, per product profile:

Partner Laboratory [Country]	Users' preferred Quality Trait	Biochemical or biophysical component predicted	Product / Sample Presentation	Total Nb of samples used for calibration dvpt (in total so far)	Database (including spectra + reference data) uploaded onto Breed Base?	Co-funding Program
Boiled Cassava						
CIAT [Colombia]	Cooking ability	water absorption	Fresh ground cassava	2905	YES	??
		OCT		250	YES	
		DM		250	YES	
		DM	Fresh Intact cassava	116	no	
		DM	Cooked Intact cassava	100	no	
NaCRRI [Uganda]	Cooking ability	DM	Fresh Grated cassava	300	??	
		Amylose		247	??	
		Root softness		100	??	
Gari Eba						
IITA [Nigeria]	Color and Textural properties	Ash Amylose Starch Sugar Protein Fat Ash Moisture	Dried ground cassava	260 260 260 260 260 260 260 260	??	??
IITA [Nigeria]	Color and Textural properties	Starch DM	Fresh ground cassava	52 130	??	??
IITA [Nigeria]	Color and Textural properties	Starch	Fresh intact cassava	208	??	NEXTGEN
		DM		240		

Partner Laboratory [Country]	Users' preferred Quality Trait	Biochemical or biophysical component predicted	Product / Sample Presentation	Total Nb of samples used for calibration dvpt (in total so far)	Database (including spectra + reference data) uploaded onto Breed Base?	Co-funding Program
IITA [Nigeria]	Color and Textural properties	Amylose Starch Sugar Solubility Swelling power Ash Moisture Dispersibilty Bulk Density Water Absorption	Unmilled Gari	48 48 48 48 48 48 48 129 129 129	??	NEXTGEN
IITA [Nigeria]	Color and Textural properties	Dispersibilty Bulk Density Water Absorption	Milled Gari	129 129 129	??	NEXTGEN
IITA [Nigeria]	Color and Textural properties	Chewiness Gumminess Adhesiveness Cohesiveness hardness	Eba	40 40 40 40 40	??	NEXTGEN
FUFU						
NRCRI [Nigeria]	??	Starch yield DM	Fresh intact cassava	175 98	??	??
NRCRI [Nigeria]	??	Moisture crude fibre Sugar Starch amylopectin amylose	Dried ground cassava	21 50 50 50 50 50	??	??

Partner Laboratory [Country]	Users' preferred Quality Trait	Biochemical or biophysical component predicted	Product / Sample Presentation	Total Nb of samples used for calibration dvpt (in total so far)	Database (including spectra + reference data) uploaded onto Breed Base?	Co-funding Program
NRCRI [Nigeria]	??	Solubility Swelling power Amylose pH DM	Fufu flour	40 40 40 42 41	??	??
NRCRI [Nigeria]	??	DM	wet mashed fufu	60	??	??
Boiled Yam						
CIRAD [France]	Cooking ability	hardness starch pectins DM	Fresh intact Yam	152 108 108 154	no	none
CIRAD [Guadeloupe]	Cooking ability	DM	Fresh Intact Yam	2150	no	none
IITA [Nigeria]	Cooking ability	DM	Fresh intact Yam	400	??	Africa Yam
IITA [Nigeria]	Cooking ability	Hardness OCT Water Absorption Starch DM	Fresh ground Yam	316 316 316 128 128	??	Africa Yam
IITA [Nigeria]	??	hardness	Boiled Yam	90	??	Africa Yam
Pounded Yam						
IITA [Nigeria]	Poundability	Luminance bad or good	Fresh ground Yam	394 200	??	Africa Yam
INRAe [Guadeloupe]	Poundability	Sugar Starch Protein	Dried ground Yam	516 516 516	??	??

Partner Laboratory [Country]	Users' preferred Quality Trait	Biochemical or biophysical component predicted	Product / Sample Presentation	Total Nb of samples used for calibration dvpt (in total so far)	Database (including spectra + reference data) uploaded onto Breed Base?	Co-funding Program
CIRAD [France]		Extensibility Springiness Adhesiveness Cohesiveness Hardness DM		174 174 174 174 174 174		
Matooke						
IITA [Uganda]	texture	Texture color	Fresh ground Banana	1312	no	??
Boiled sweet potato						
CIP [Uganda]	Cooking ability	DM Starch Amylose in starch Amylose Fructose Glucose Saccharose Solubility Swelling power Pasting time Pasting temperature Peak viscosity Trough Final viscosity Breakdown Setback Pasting time	Fresh intact sweet potato	225 225 225 225 225 225 225 225 225 225 225 225 225 225 225 225 225	??	??

Partner Laboratory [Country]	Users' preferred Quality Trait	Biochemical or biophysical component predicted	Product / Sample Presentation	Total Nb of samples used for calibration dvpt (in total so far)	Database (including spectra + reference data) uploaded onto Breed Base?	Co-funding Program
		Pasting temperature Peak viscosity Trough Final viscosity Breakdown Setback OCT Firmness Toughness		225 225 225 225 225 225 183 183 183		
CIP [Uganda]	Cooking ability	sensorial profiles	Fresh intact sweet potato	2359	no	SweetGains
CIP [Uganda]	Cooking ability	Color mealiness	Fresh intact sweet potato	360	no	SweetGains
CIP [Uganda]	Cooking ability	sensorial profiles	Fresh mashed sweet potato	1043	no	SweetGains
CIP [Uganda]	Cooking ability	sensorial profiles	Fresh freeze-dried ground sweet potato	102	no	SweetGains
CIP [Uganda]	Cooking ability	sensorial profiles	Cooked intact sweet potato	360	no	SweetGains
CIP [Uganda]	Cooking ability	sensorial profiles	Cooked mashed sweet potato	2023	no	SweetGains
CIP [Uganda]	Cooking ability	sensorial profiles	cooked freeze-dried ground sweet potato	69	no	SweetGains
Boiled potato						
CIP [Uganda]	Cooking ability	sensorial profiles	Fresh intact potato	390	no	USAID Feed the Future

Partner Laboratory [Country]	Users' preferred Quality Trait	Biochemical or biophysical component predicted	Product / Sample Presentation	Total Nb of samples used for calibration dvpt (in total so far)	Database (including spectra + reference data) uploaded onto Breed Base?	Co-funding Program
						Crops to End Hunger 23 award no: DIS-B-AID-BFS-IO-17-00005
CIP [Uganda]	Cooking ability	sensorial profiles	Cooked intact potato	390	no	USAID Feed the Future Crops to End Hunger 23 award no: DIS-B-AID-BFS-IO-17-00005

3.3 Publications

Fabrice DAVRIEUX, Karima MEGHAR (2018). High -Throughput Phenotyping Protocols (HTPP). State Of Knowledge. Work Package 3. Saint-Pierre de La Réunion (France). RTBfoods Project Report, 30 p. https://doi.org/10.18167/agritrop/00739

Karima MEGHAR, (2019). Hyperspectral Imaging Applied to RTB crops and products High-throughput phenotyping protocols (HTPP) - Work Package 3. Montpellier, France: RTBfoods Project Report, 22p. https://doi.org/10.18167/agritrop/00740

Emmanuel Oladeji Alamu, Ephraim Nuwamanya, Denis Cornet, Karima Meghar, Michael Adesokan, Thierry Tran, John Belalcazar, Lucienne Desfontaines & Fabrice Davrieux (2021). Near-infrared spectroscopy applications for high-throughput phenotyping for cassava and yam: A review. *International Journal of Food science and Technology,* **56**(3), 1491-1446. https://doi.org/10.1111/ijfs.14773

Ehounou AE, Cornet D, Desfontaines L, Marie-Magdelaine C, Maledon E, Nudol E, Beurier G, Rouan L, Brat P, Lechaudel M, Nous C, N'guetta Assanvo, Kouakou Amani M, Arnau G. (2021). Predicting quality, texture and chemical content of yam (*Dioscorea alata* L.) tubers using near infrared spectroscopy. *Journal of Near Infrared Spectroscopy,* 29(3), 128-139. https://doi.org/10.1177/09670335211007575

Emmanuel Oladeji Alamu, Michael Adesokan, Asrat Asfaw &Busie Maziya-Dixon (2020). Effect of Sample Preparation Methods on the Prediction Performances of Near Infrared Reflectance Spectroscopy for Quality Traits of Fresh Yam (*Dioscorea spp.). Applied Sciences-Basel,* **10**(17), n°6035; https://doi.org/10.3390/app10176035

Karima Meghar, Thierry Tran, Luis Fernando Delgado, Maria Alejandra Ospina, Jhon Larry Moreno, Jorge Luna, Luis Londoño, Dominique Dufour, Fabrice Davrieux (2023). Hyperspectral imaging for the determination of relevant cooking quality traits of boiled cassava. Journal of the Science of Food and Agriculture, submitted.

Houngbo Mahugnon Ezékiel, Desfontaines Lucienne, Diman Jean-Louis, Arnau Gemma, Mestres Christian, Davrieux Fabrice, Rouan Lauriane, Beurier Grégory, Marie-Magdeleine Carine, Meghar Karima, Alamu Emmanuel Oladeji, Otegbayo Bolanle, Cornet Denis (2023). Convolutional neural network allows amylose content prediction in yam (Dioscorea alata L) flour using near infrared spectroscopy. Journal of the Science of Food and Agriculture, submitted.

Laurent Adinsi, Imayath Djibril-Moussa, Laurenda Honfozo, Alexandre Bouniol, Karima Meghar, Emmanuel O. Alamu, Michael Adesokan, Santiago Arufe, Miriam Ofoeze, Benjamin Okoye, Tessy Madu, Francis Hotègni, Ugo Chijioke, Bolanle Otegbayo, Joseph D. Hounhouigan, Christian Mestres, and Noël H. Akissoé (2023). Characterising quality traits of boiled yam: texture and taste for enhanced breeding efficiency and impact. Journal of the Science of Food and Agriculture, submitted.

Elizabeth Arnaud, Naama Menda, Amos Asiimwe, Karima Meghar, Marie-Angélique Laporte, Lora Forsythe, Afolabi Agbona, Robert Kawuki, Michael Kanaabi, Bryan Ellebrock, Xiaofei Zhang, Thierry Tran, Reuben Ssali, Asrat Asfaw Amele, Ismail Siraj Kayondo, Brigitte Uwimana, Ernest Chukwudi, Godwill Makunde, Mariam Nakitto , Isabelle Maraval, Lukas Muller, Alexandre Bouniol (2023). Connecting Consumer Preferences, Food Quality and Breeding Data for Market-oriented Breeding of Roots, Tubers, and Banana Crops. Journal of the Science of Food and Agriculture, submitted.

Judith S Nantongo, Edwin Serunkuma, Mariam Nakitto, Gabriela Burgos, Fabrice Davrieux, Thomas Zum Felde, Eduardo Porras, Ted Carey, Jolien Swankaert, Robert Mwanga, Reuben Ssali (2023). NIRS models to predict sensory and texture traits of sweetpotato roots. Journal of the Science of Food and Agriculture, submitted.

Kanaabi Michael, Ephraim Nuwamanya, Fatumah Babirye Namakula, Nicholas Muhumuza, Enoch Wembabazi,Titus Alicai, Paula Iragaba, Kayondo Siraj Ismail, Williams Esuma, Alfred Ozimati, Julius Baguma, Nanyonjo A. Ritah, Leah Nandudu, Mukasa S.B., Phinehas Tukamuhabwa, and Robert S. Kawuki (2023). Rapid Analysis of Cyanogenic Potential in Fresh Cassava Roots Using NIRS. Journal of the Science of Food and Agriculture, submitted.

3.4 Management of spectral data for efficient use by breeding teams

Narrative on Data Management at WP level

The first year of the project a specific template (excel file) was defined collectively and adopted by the different teams. The template collects information about: the institutes and analysts involved, and the samples (origin, type, year, presentation, type of instrument, SOP applied…). The spectral data and biochemical data are also collected using this template. If a calibration exists a description (method used, type of validation, performances…) of the calibration is reported in the template. Once the template filled by the teams, a control of conformity is done at WP level, and if corrections or complements are needed the template is sent back to the teams for correction. This process is done until final validation by the coordination team.

transfer of spectral data onto BreedBase.

In the RTBfoods project, we were expected to upload all NIRS data generated. Over the 5 years, 21844 NIRS spectra of fresh, grated cassava roots, and fresh or boiled yam tubers have been uploaded to date into the respective Cassavabase and Yambase. The number of spectra uploaded into Breedbase by institute, crop, product, and trial is shown in Table 1. Until now, 249, 16884, 1759, 2952 NIR spectra were uploaded by CIRAD, IITA, CIAT and NaCCRI respectively.

Table 1: *Number of spectral data available in BreedBase per partner, per crop & food product*

Institute	Crop	Product	BreedBase	Breeding program ?	Trial name	Number of spectra uploaded
CIRAD	Yam	Boiled yam	YamBase	No	_____	249
IITA	Cassava	Grated cassava	CassavaBase	Yes	20.CASS.PYT.52.IK	1707
IITA	Cassava	Grated cassava	CassavaBase	Yes	20.CMSSurveyVarieties.AYT.33.IB	1170
IITA	Cassava	Grated cassava	CassavaBase	Yes	20.GS.C1.C2.UYT.36.SETA.IB	1284
IITA	Cassava	Grated cassava	CassavaBase	Yes	20.GS.C1.C2.UYT.36.SETB.IB	1292
IITA	Cassava	Grated cassava	CassavaBase	Yes	20.GS.C4B.AYT.40.IB	1440
IITA	Cassava	Grated cassava	CassavaBase	Yes	20.GS.C4B.AYT.42.AG	1309
IITA	Cassava	Grated cassava	CassavaBase	Yes	20.GS.C4B.PYT.500.IK	8682
CIAT	Cassava	Boiled cassava	CassavaBase	Yes	201903CQQU1_ciat	104
CIAT	Cassava	Boiled cassava	CassavaBase	Yes	2019111CQQU1_ciat	56
CIAT	Cassava	Boiled cassava	CassavaBase	Yes	202022CQQU1_ciat	90
CIAT	Cassava	Boiled cassava	CassavaBase	Yes	202102CQQU1_ciat	93
CIAT	Cassava	Boiled cassava	CassavaBase	Yes	202023CQQU2_ciat	479
CIAT	Cassava	Boiled cassava	CassavaBase	Yes	202002CQQU1_ciat	395
CIAT	Cassava	Boiled cassava	CassavaBase	Yes	202108CQQU2_ciat	542
NaCRRI	Cassava	Boiled cassava	CassavaBase	Yes	2021_Pre-breeding_CET_Namulonge	676
NaCRRI	Cassava	Boiled cassava	CassavaBase	Yes	2021_C2_CET_GWAS_Ngetta	435
NaCRRI	Cassava	Boiled cassava	CassavaBase	Yes	2020_C2_AYT_Namulonge	141
NaCRRI	Cassava	Boiled cassava	CassavaBase	Yes	C2_Serere_GWAS_CET_2019	1004
NaCRRI	Cassava	Boiled cassava	CassavaBase	Yes	C2_CET_GWAS_Namulonge_2019	265
NaCRRI	Cassava	Boiled cassava	CassavaBase	Yes	LA_UYT_Yellow_Serere_2019	26
NaCRRI	Cassava	Boiled cassava	CassavaBase	Yes	AYT_b_Namulonge_2019	17
NaCRRI	Cassava	Boiled cassava	CassavaBase	Yes	WA_Selections_Serere_2019	34
NaCRRI	Cassava	Boiled cassava	CassavaBase	Yes	Genetic_Gain_Namulonge_2019	34
NaCRRI	Cassava	Boiled cassava	CassavaBase	Yes	LA_Selections_Serere_2019	25
NaCRRI	Cassava	Boiled cassava	CassavaBase	Yes	Genetic_Gain_Loro_2019	27
NaCRRI	Cassava	Boiled cassava	CassavaBase	Yes	WA_Selections_Namulonge_2019	55
NaCRRI	Cassava	Boiled cassava	CassavaBase	Yes	Genetic_Gain_Serere	50
NaCRRI	Cassava	Boiled cassava	CassavaBase	Yes	RTB_Serere_TP_2018	65
NaCRRI	Cassava	Boiled cassava	CassavaBase	Yes	RTB_Serere_Namulonge_2018	98

Priority next steps for the storage of spectral data on BreedBase,. to make on-going calibration models and spectra acquired on breeding genotypes available to breeders for selection purposes.

In the first phase of RTBfoods, we started to upload NIRS data from period 4. During this period, we faced some challenges: (1) Our data were not compatible with the format required by the BTI; (2) lack of staff in charge of the data storage into Breedbase; (3) Only NIR spectra from breeding program could be stored. All of these challenges have caused delays in storage of NIRS data in BreedBase. For the next phase, the priority will be the finalisation of uploading of the missing NIRS data.

4 WP3 STRATEGY FOR CAPACITY STRENGTHENING OF PARTNERS

4.1 Acquisition of mid- & high-throughput equipments by partners

The coordination teams have supported and advised teams in their approach to strengthen their capacities. Actually, two main brand-new instruments were acquired during the project: two hyper spectral cameras, Specim FX 17 (Specim, Oulu, Finland). One was acquired by CIRAD (France) and one by IITA (Nigeria). The system was first acquired at CIRAD and training was carried out by the company supplying the instrument. Then the people trained were able to advise and train the IITA researchers during their acquisition. A 10-day mission by K. Meghar was carried out at IITA, Ibadan, Nigeria to provide this training.

CIAT, Colombia purchased a portable NIRS (QualitySpec, ASD, Malvern Panalytical, Malvern, UK), the funding came mainly from RTBfoods and NextGen projects. The coordination teams gave support for use of this instrument for routine analysis and shared with CIAT analysts the SOPs developed (in NaCRRI and in NRCRI) for cassava measurement using this instrument. A specific experimental design was decided between WP3 coordination and CIAT researchers in order to transfer calibration developed on the benchtop instrument (FOSS, DS2500) to this one.

It is important to note that a portable spectrometer (qualitySpec, ASD) funded by the NextGen project has been acquired by the NaCRRI. this instrument has largely contributed to the spectral bases developed for: fresh cassava (NaCRRI, Ugnada) and matooke (IITA, Uganda).

4.2 Trainings & support to partners

During the 5 years of the project a continuum has been maintained in the training and support of researchers and analysts. This is translated into 14 official training sessions. Beyond these sessions, permanent exchanges were carried out with the teams to respond to specific analytical issues.

The training was initiated from the first year, with 5 training sessions with the following main objective: To improve knowledge on principles of NIR spectroscopy and needed laboratory conditions. The trainings took place in Uganda (2), Nigeria and Peru and 1 to 19 participants were involved in the training sessions depending on the place and purpose. For this first period the common outcomes of these sessions were 1) Strengthening of the laboratory capacities 2) a clear evaluation of the state of knowledge and know-how of the existing NIRS teams 3) definition of the protocols for sampling and routine analysis 4) identification of the persons in charge of the NIRS management and development.

During the second period, 2 training sessions, one in IITA (Nigeria, Ibadan, 2 weeks) and one in NaCRRI (Uganda, Namulonge, 1 week) were organized to go further in the processing of data and the development of calibrations. These sessions were open to all RTBfoods partners working under WP3 and other project partners, such as NextGen. These sessions cover all theorical aspects from data acquisition to calibration development. A specific time was dedicated to practice from sample preparation, spectra measurement, spectra exportation, and calibration development. A specific training was done for software (Winisi©, FOSS and Unscrambler©, AspenTech). The trainers shared all presentations given during the training and data management templates with the participants on a USB stick.

Despite the COVID crisis, which impacted periods 3 and 4, the training program was continued first in the form of webinars and master classes and then through the mission on site. Over this period, 4 training courses were carried out : 1) an online Masterclass on spectral representativeness, with a special focus on fresh intact roots and tubers 2) a training session (15 days, IITA, Ibadan, Nigeria) on spectral acquisition and images treatments using an HSI Camera 3) a training session (5 days, NRCRI, Ibadan, Nigeria) on fresh cassava measurement and calibration development using a portable NIR spectrometer 4) a special training during the AfricaYam meeting (Cotonou, Benin) on NIRS Theory and calibration concepts 5) a special training during the AfricaYam meeting (Cotonou, Benin) on Color measurements using imaging.

During period 5, support and training was mainly carried out through remote support specific to teams for well-identified calibration or data processing problems. which was the case for the calibrations of cassava cooking time (CIAT), for the processing of HSI images (IITA) or for the cleaning of spectral data (IITTA and NaCRRI, Uganda). however, two training missions were carried out in period 5: 1) training mission in phenotyping tools and methods applied to the improvement of yam at the CNRA (Côte d'Ivoire) and 2) support mission for the treatment of calibration data and development applied to cassava, sweet potatoes and matooke at NaCRRI (Uganda)

The training in CNRA (2 weeks) was dedicated to statistics and modelisation using R© software and to theory and application of near infrared spectroscopy for phenotyping. Practical lessons including exercises and examples were provided. all course materials and work data have been shared with participants.

The mission (2 weeks) in NARO research centre in Namulonge in Uganda had two objectives 1) to audit the databases and calibrations developed from near infrared spectral data for cassava (NaCRRI), for sweet potato and potato (CIP) and for banana (Matooke, IITA); 2) define and validate, with the partners, the deliverables expected for 2022 and the end-of-project deliverables.

4.3 Scientific collaborations between partners

NRCRI & IITA in Nigeria on Cassava & Yam

Both institutes exchanged protocols for the XDS spectrometer and data transfer from ASD spectrometer to XDS instrument. IITA provided supports on spectra analysis of cassava genotypes for mealiness and hosted the training support on ASD for NRCRI. IITA made the portable spectrometer available to the NRCRI to replace their broken-down instrument. Dr E. Alamu (IITA) was, as co-coordinator of WP3, the scientific referent for NRCRI and Bowen university.

CIAT in Colombia & CIRAD Montpellier Cassava

CIAT and CIRAD worked together to set up SOPs for texture and water absorption measurements and for spectral measurements on fresh cassava. CIRAD provided CIAT with the hyperspecral camera to carry out measurements during the 2022 harvest. CIRAD and CIAT have jointly developed a calibration for quantifying water absorption from fresh cassava spectra .

CIAT in Colombia & NaCRRI in Uganda on Cassava

Scientific collaborations between NaCRRI and CIAT concerned mainly WP2 activities, such as sharing of experience and protocols. Regarding WP3 the collaboration focused on the implementation of similar SOPs for spectral acquisition on fresh cassava.

INRAe & CIRAD & CNRA in Guadeloupe on Yam

There was an important implication of the three partners to achieve the goal of developing a calibration model for primary compounds and textural parameters on yam tuber flour. The collaboration between CIRAD UMR-Agap, INRAe and CNRA allowed a publication on yam composition, texture and mouldability prediction using NIRS and deep learning. The collaboration between INRAe and Cirad UMR-Agap allows to develop a SOP on starch grain characterization and to build a database on these traits. CIRAD hosted Dr Dibi from CNRA during 2 months in Montpellier in order to give training on yam phenotyping method.

NaCRRI & IITA in Uganda on Matooke

Both institutes worked on the standard protocols for sample preparations for the spectra data collection using Handheld NIRS for fresh intact and mashed banana. NaCRRI, through the nutrition and Bioanalytical Laboratory, has supported the Banana breeding team at IITA through spectral acquisition, generation of reference information and undertaking proof of concepts for Matooke.

NaCRRI & CIP in Uganda on Sweetpotato

NaCRRI houses CIP's cooking facility, including the preparation room, kitchen and CIP's texture analyzer in its Biosciences laboratory. These facilities have so far been crucial for preparing samples and analyzing for texture attributes. NaCRRI & CIP in Uganda organized a 1-week NIRS training together in Namulonge sharing their facilities.

Success Story Box n°3:

The use of image analysis to characterize the color of RTB products in Côte d'Ivoire by the CNRA.

The characterization of color is an essential criterion for the majority of RTB product profiles. The heterogeneity of the color and the rough aspect of the studied surfaces make the use of the chromameter difficult. This is why CIRAD has developed a method for monitoring color and oxidation by image analysis. In order to appropriate this method, CNRA participated in the AfricaYam / RTBfoods Training on Yam Quality Evaluation from 22 to 26 November 2021. At the same time, a CNRA researcher was hosted at CIRAD Montpellier from September 15 to November 15, 2021, in order to learn about the various phenotyping techniques. This stay allowed to review the different steps of the method described in the 3 SOPs. After this visit, CNRA Bouaké built a photo studio equipped for image acquisition and created its own custom reference color chart. At the beginning of 2022, a first series of images was acquired by the CNRA on the yam collections of Bouake. A support mission from CIRAD in June 2022 made it possible to work on these images and to improve their acquisition method. A technician was dedicated to this specific task. The CNRA Bouake is now operational to characterize the color of the various RTB products!

4.4 Lessons learnt for the next phase

- Obviously, what did not work well was the more regular follow-up of the calibrations development, particularly their performance and how these were evaluated (validation). Added to this is a lack of a more rigorous assessment of their perfect match with the project's expectations.

This was the result of several factors. First, with a late definition of priority quality traits, the teams developed calibrations on traits they already knew how to do in the laboratory. Then, for most of the crops, the harvests were late, which led to a late availability of data (at the end of the period) and therefore limited the time needed for effective interactions before restitution. And even before being able to evaluate the work in depth, a new cycle began.

- Another observation concerns the lack of perenniality of some of the spectral bases and the associated calibrations. that is to say that certain bases were started and then abandoned in the following years or started again without continuity with the previous one even though it involved the same protocols for the same quality traits.

Again, this is due to a delay in the definition of priority traits, leading the teams to test leads without a long-term vision, but this is also due to a lack of organization and time from the coordination team to concatenate these different bases.

- The last point concerns the quality of the models developed, which is below expectations for a majority of the quality traits.

This is due to three factors: the WP2 protocols used were not available or finalized and therefore less precise measurements, a lack of experience of the teams for the development of models and finally unsuitable methodical approaches for certain quality traits (quantification instead of classification for example)

In order to correct all these points, it will be necessary to strengthen (even to merge) the links between WP2 and WP3. Then to only work on traits for which validated WP2 SOPs exist. At the coordination level it will be a question of setting up strict procedures for 1) cleaning and validating the databases, 2) co-development of calibrations with the teams and 3) defining standard procedures for validation in prediction and in classification.

With regard to coordination and support to partners, what should be particularly emphasised/planned in the next phase to ensure continuous and well-adjusted capacity strengthening of partners?

For the next phase, efforts must be concentrated on training (there has been a lot of turnover within the teams) and on monitoring the instruments and their proper use. Special effort will be done on joint work (with researchers) for cleaning the databases and developing calibrations. A scientific committee within WP3 will be in charge of evaluating and validating the predictive models developed. This committee would be made up of WP2 and WP3 researchers representative of the different institutes.

5 INTERACTION MECHANISMS BETWEEN WPS

With WP2:

In general, the collaborations between WP2 and WP3 worked well, this being partly because the researchers were involved in both WPs. Despite this, there was often a lack of feedback once the models were established and, therefore, a lack of back and forth between the 2 WPs to improve or adapt these models.

The best way to improve this will be to strengthen the involvement of researchers from both WPs and to make model accuracy a common objective. This will go through a co-development of calibrations

With WP4:

There were organised joint meetings and close links in the coordination of both work packages. However, there is a need to set up robust and effective traceability of the plant material provided by the wp4 and analysed by the wp3.

With WP6-PMU:

WP6 gave support for meetings organization and minutes recording. Support for interaction with the different partners involved in WP3 and support for interaction with WP2 and WP4 coordination teams.

6 COMPLEMENTARITY WITH OTHER PROJECTS OR BREEDING PROGRAMS ON RTB CROPS

Country	Institute	Product Profile	Complementary Projects/Initiatives	Points of complementarity / Activities performed &/or funded jointly
Uganda	NaCRRI	Boiled Cassava	NEXTGEN	Participate to the acquisition of the portable spectrometer (QualitySpec, ASD)
Colombia	CIAT	Boiled Cassava	NEXTGEN, RTB	Participate to the acquisition of the portable spectrometer (QualitySpec, ASD)
Nigeria	NRCRI	Gari-Eba	NEXTGEN	The Nextgen cassava project provided project vehicles and human resources that helped us during on-station and out-station evaluations. Nextgen cassava also provided technical and financial support to facilitate repairs of NIRS.
Nigeria	NRCRI	Fufu	NEXTGEN	The Nextgen cassava project provided project vehicles and human resources that helped us during on-station and out-station evaluations. Nextgen cassava also provided technical and financial support to facilitate repairs of NIRS.
Nigeria	NRCRI	Boiled & Pounded Yam	AfricaYam	The Africa yam project provided vehicles and human resources that helped us during on-station and out-station evaluations.
Nigeria	IITA	Gari-Eba	NEXTGEN	The NEXTGEN project provided the breeding materials and human resources whenever required and collaborated on the acquisition of spectra using tabletop NIRS and portable NIRS. Also, it contributed to the cost of Hyperspectral imaging equipment acquired recently.
Nigeria	IITA	Fufu	NEXTGEN	None
Nigeria	IITA	Boiled & Pounded Yam	AfricaYam	The Africa Yam project provided the breeding materials and human resources whenever required and collaborated on the acquisition of spectra using tabletop NIRS. Also, it contributed to the cost of Hyperspectral imaging equipment acquired recently.
France	CIRAD	Boiled Yam	AfricaYam	The project AfricaYam provides contrasted Yam varieties for HSI analysis
Guadeloupe	CIRAD/ INRAe	Boiled/Pounded Yam	AfricaYam	Africa Yam, in Guadeloupe, contribute to the field preparation and maintenance over the 5 years of the project. Moreover, while RTBfoods financed the work on development yam quality phenotyping, AfricaYam allow the development of agronomy related trait phenotyping. Cirad financed half of the PhD thesis cost of Ezékiel Houngbo one of whose objectives is to make the link between growth, development and quality of yam. Cirad also financed half of the purchase cost of the portable spectrometer (~30k€) to ensure the continuity of quality phenotyping activities in Guadeloupe.

Country	Institute	Product Profile	Complementary Projects/Initiatives	Points of complementarity / Activities performed &/or funded jointly
Uganda	NaCRRI/ NARL/ IITA	Matooke	ABBB	(Brigitte Uwimana ; Ephraim Nuwamanya)
Uganda	CIP	Boiled Sweepotato	SweetGains	1.SweetGAINS supported the establishment of breeding trials to provide roots for the various experiments 2.SweetGAINS purchased the Digieye machine and offered a subgrant agreement to Makerere University to develop calibrations for mealiness from image analysis
Uganda	CIP	Boiled Potato	USAID Feed the Future Crops to End Hunger 23 award no: DIS-B-AID-BFS-IO-17-	USAID supported the establishment and maintenance of potato breeding trials to provide tubers for the various experiments

7 REMAINING CHALLENGES & PERSPECTIVES FOR THE NEXT PHASE

The project has highlighted critical points regarding the development of high-throughput phenotyping methods. Firstly, developing efficient models (NIRS, MIRS, or hyper spectral images) is very difficult based on texture data obtained by physical measurements or sensory analysis. This is due to 1) an insufficiently rigorous methodology in the analytical chain 2) the fact that the biochemical constituents involved in the physical properties have a minor impact on the spectral fingerprint. In this sense, imaging (DigiEye or high-resolution images) together with image processing algorithms and deep learning tools looks promising and should be investigated further. Developments involving physical (textures) & sensory data should be oriented towards classification models based on thresholds defined by WP2 and consumers.

the other critical point concerns the durability of the spectral bases and the validation of the calibrations developed. Too many databases developed for a given product and measurement mode have not been enhanced over the years. In some cases, several bases were initiated according to the trait measured and not according to the product and its mode of measurement. A database developed, for example, for intact fresh cassava must be continued regardless of the targeted/measured quality trait, the type of spectrum always remains the same, and the richness of the metadata (genotype, origin, age, etc.) ultimately allows the enrichment of the spectral base. In addition, a lack of follow-up (maintenance) of the instruments and the absence of standardization weaken the sustainability of the bases.

The last critical point concerns a recommendation from the advisory committee: priority must be given to analysing fresh products that are as little processed as possible.

The remaining scientific & technical challenges to be overcome within the next 2 years are:

- • Effort on the rigor of the implementation of the analytical chain: sampling - physico-chemical & sensory measurement - spectral measurements - modeling - external validation
- Increase robustness of current NIRS models using external validation and continuous model enrichment
- Capacity enhancement on equipment maintenance Support for the use of free and open source software, exchange of scripts.
- Use future acceptability thresholds (from WP2) to calibrate dedicated classification models using NIRS
- strengthen proof of concept for the characterization of quality traits from measurements on fresh products
- Application of hyperspectral imaging for the characterization of the spatial distributions of constituents (homogeneity) within roots and tubers. Study of the relationships between levels of homogeneity and physical properties and aptitude for transformation. Developing specific scripts for data management, calibration development, image analysis…, using a common language.
- Thinking the best solution for images and HIS images storage and sharing.
- Creating web interface for deep learning/PLS models to share and apply the models in routine analysis.

7.1 Proposed activities:

Cassava / Boiled cassava

CIRAD (Qualisud, France) & CIAT (Colombia): The work on the characterization of Cassava cooking ability using NIRS will be continued. This work will be done in Colombia, in collaboration with CIAT. During the next harvest season, April 2023, a scientific mission will be held (Fabrice Davrieux) in Cali Colombia with four objectives:1) consolidate the already operational model 2) define the acceptability threshold for WA30 classification, 3) write a scientific article reporting the results 4) to start transfer of calibration onto QualitySpec instrument. These activities will be conducted by F. Davrieux (CIRAD, France), T Tran (CIRAD-CIAT, France), K. Meghar (CIRAD, France), Z. Xiaofei (Alliance Bioversity-CIAT, Colombia) and L. Londono (HarvestPlus - Alliance Bioversity-CIAT, Colombia).

CIRAD (Qualisud, France) Support Food & Nutritional Science Lab team of IITA in the deployment of HSI as a breeding tool. Mickael Adesokan, Phd student from IITA will come to CIRAD for 2 months of internship. The objectives are to (i) understand the principles of chemometrics and multivariate analysis involved in processing hyperspectral images. (ii) to learn the development of calibration models for characterising quality traits of Gari/Eba and Boiled yam using HSI. (iii) The images generated from cassava and yam products using the Hyperspectral camera in IITA will be processed and used for model development during the internship. These activities will be conducted by K. Meghar (CIRAD, France), M. Adesokan (IITA, Nigeria) and E. Alamu (IITA, Zambia).

NaCRRI (Uganda): A specific scientific support will be purchased with the NaCRRI cassava team for calibration enhancement especially for DM, Amylose and HCN quantification. An effort will be done for developing efficient models for characterization of cassava cooking ability using water absorption, on the base of what is done in CIAT (probably with transfer of calibrations). Work on softness of boiled roots will be continued. Need for (i) support through scientific missions (F. Davrieux, CIRAD, Réunion), (ii) purchase and avail a commercial license of Xlstat software, (iii) facilitation of technician for routine maintenance of NIRS and texture analyzer platforms and (iiii) project staff retooling. Scientific involved: Ephraim Nuwamanya (NaCRRI), Fatumah Babirye (NaCRRI), Michael Kanaabi (NaCRRI) and Enoch Wembabazi (NacRRI).

NRCRI (Nigeria): Standardize sample and calibration procedure for predicting cassava retting ability using dry matter content by NIRS. Expand and consolidate the calibration procedure for predicting instrumental texture attribute of fufu and ease of peel. The NRCRI team involved in this activity will comprise Enerst Chukwudi Ogbete, Ugo Chijioke, Oluchi Achonwa, Ugochi Iro, Nwamaka Ogunka, Sonia Osadeke, Justice Okoronkwo, Juilet Chikere, Precious Udoka and Ijeoma Obasi, Chiedozie Egesi, Damian Njoku, Lydia Ezenwaka, Simeon Peter Abah, Ezenwanyi uba. CIRAD scientists include Toyin Ayetigbo, Alexandra Bouniol, Amos Asiimwe, Fabrice Davrieux. IITA members will include Emmanuel Alamu and Micheal Adesokan

Yam / Boiled Yam

CIRAD (Qualisud & Agap, France): In order to address key driver of acceptability, NIRS prediction database need to be collected jointly with texture reference measures in Guadeloupe. This will allow to test the feasibility to predict texture quality from NIRS on raw fresh yam. Based on the identified acceptability thresholds, it will be necessary to develop predictive classification models that will allow rapid and accurate screening for breeders. Most NIRS database are not uploaded to the yam base and will require active investment to do so.

CIRAD (Qualisud, France): Improvement of the HSI-based models developed during the project to predict the cooking ability of yam (Guadeloupe) and cassava (CIAT) genotypes. For this, the image databases will be supplemented by the analysis of new genotypes with contrasting behaviors. For these images, the composition of each pixel will be predicted from the models and an image homogeneity index will be defined. The relationship between this index and cooking behavior (texture, water absorption, time, etc.) will be studied with the aim of classifying genotypes according to their ability to cook. K. Meghar (CIRAD, France), M. Lechaudel (CIRAD, Guadeloupe), F. Davrieux (CIRAD), T Tran (CIRAD-CIAT, France), Z. Xiaofei (Alliance Bioversity-CIAT, Colombia) and L. Londono (HarvestPlus - Alliance Bioversity-CIAT, Colombia)

IITA (NIGERIA): (i) develop SOPs for sample collections and evaluation of key traits of fresh and boiled yam using HSI (ii) characterization of acceptable genotypes from RTBfoods populations for key biophysical, textural traits of boiled yam using HSI

Sweetpotato and potato / boiled sweetpotato and potato:

CIP (unganda). The work on characterization of cooking (frying and boiling) ability of sweet potatoes and potatoes started during the RTBfoods project will be continued. The objectives are to identify 2 or 3 relevant traits, such as color, water absorption, sensorial profiles that could be calibrated using NIRS. The activities will concentrate all the efforts onto experimental design, sampling, analyses sensorial physical and biochemical and model developments. This will be done during scientific mission during harvest and analyses periods and online support for model development. The scientific involved in these activities are from CIP: Serunkuma, Edwin, Ssali Nantongo, Judith and Nakitto Mariam, from CIRAD: F. Davrieux, K. Meghar and from COCIS, Kampala University: Joyce Nabende.

CIRAD (Qualisud, France) In collaboration with CIP and COCIS (Uganda), CIRAD will develop a Python script for the processing of HSI images. The steps will to be including in the script are: image correction, segmentation, unfolding and development of calibration. This script will be used as free tool by partners involved in HSI analyses (IITA, CIAT and CIRAD). The scientific involved in these activities are from CIP: J. Ssali Nantongo, from CIRAD: K. Meghar and F. Davrieux and from COCIS, Kampala University: J. Nabende

Cassava / Gari-Eba

IITA (NIGERIA): (i) develop SOPs for sample collections and evaluation of key traits of fresh cassava using HSI (ii) characterization of acceptable genotypes from RTBfoods populations for key biophysical, textural traits of Gari/Eba using HSI.

Yam / Pounded Yam:

CIRAD (Qualisud & Agap) France – Guadeloupe – UAC-FSA (Benin): Classification of Yam genotypes according to their pounding ability (poor or good) using NIRS. the study will be done in Benin (UAC-FSA) and Guadeloupe where contrasting varieties are available. NIRS measurements will be carried out on slices of fresh yam. Pounding time and sound during pounding will be recorded, opinion of the preparer (0=poor, 1=average, 2=good) and the panel opinion (0=poor, 1=average, 2=good) will be recorded. The decision to provide a spectrometer on the production site (Benin/Guadeloupe) or to collect and analyse the samples in France (Montpellier) will be taken collectively at the start of the second phase. The scientific involved in these activities are from UAC-FSA: Noel Akissoe and from CIRAD: Fabrice Davrieux, Denis Cornet, Alexandre Bouniol and Karima Meghar, and Alexandre Dansi

CIRAD (Qualisud & Agap**) France-Guadeloupe – INRAE (Guadeloupe)**: In order to address key driver of acceptability, NIRS prediction database need to be collected jointly with texture reference measures in Guadeloupe. This will allow to test the feasibility to predict texture quality from NIRS on raw fresh yam.

Amylose content and mouldability, two major traits for pounded yam quality still need external validation that will be carried on during next phase.

Based on the identified acceptability thresholds, it will be necessary to develop predictive classification models that will allow rapid and accurate screening for breeders.

Most NIRS databases are not uploaded to the yam base and will require active investment to do so

IITA (NIGERIA): (i) Examine model for available traits to take decision (ii). Improve/validate the working calibration models for Water absorption and textural traits (double cross-validation). Capacity building is required for chemometric and software support training for the Hyperspectral camera. The IITA Team will include Emmanuel Alamu, Adesokan Michael, Asrat Amele, Agre Pate, and Busie Maziya-Dixon.

Matooke

NARL (Uganda): Rapid kitchen methods for screening matooke genotype samples will be completed. Also the process to develop a NIRS-based high throughput selection methods will be continued. Building on work done under RTBFoods phase I, calibration models and Validation of the NIRS models on Matooke will be done. The NARL scientists involved will include Henry Buregyeya and Sarah Kisakye in collaboration with Ephraim Nuwamanya of NaCRRI and Fabrice, Davrieuxof CIRAD. The matooke breeding team requires at least a hand-NIRS equipment to use in validation of the NIRS based screening tools.The matooke team will also need support in NIRS calibration and validation of the calibration models.

Yam (to be confirmed))

UAC-FSA :Many SOPs on texture were developed at each institute level, which differed by little considerations. We will harmonize, in collaboration with CIRAD and IITA, all the available SOPs on textural (MTM), NIRS (HTM) and MAS (HTM), HSI, Image analysis (HTM), color (Chromameter: MTP). In UAC-FSA, Noël Akissoé, Laurent Adinsi and a Master food scientist will be involved in this activity. As soon as possible, we need training on NIRS (HTM) and MAS (HTM), HSI, Image analysis (HTM)

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