Outcome Evaluation Report

Outcome Evaluation of the RTBfoods Project

Management Team, WP6

Paris, France, December 2022

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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 study has been undertaken as part of the final assessment of the project. It helped the project team in assessing the progress made toward the expected outcomes and in formulating recommendations for the way forward. It was also part of Cirad's institutional efforts to promote a "culture of impact". The study was funded and supported by Cirad as first pilot of an internal mechanism fostering the use of impact and outcome evaluations as reflexive exercises to generate knowledge and learn lessons on the contributions and contribution pathways of research to societal impacts.

The evaluation was realized between June and December 2022 by a mixed evaluation team composed by one external evaluator from Quadrant Conseil, one evaluator from Cirad ImpresS team and the RTBfoods project manager for monitoring, evaluation and learning (MEL). The outcome harvesting method has been adapted and used. Participatory workshops, exploratory interviews, an online survey, in-depth bilateral interviews and documentary analysis were used as main tools for the identification and the substantiation of project outcomes.

The evaluation found that the project strengthened partners' capacities for the development and use of:

- participatory and gender-sensitive methods and tools to understand user needs and preferences;
- food product profiles;
- standard operating procedures to assess quality traits;
- a set of low, medium and high-throughput phenotyping protocols to measure and predicts quality traits. Both technical and equipment capacities were strengthened in this field;
- harmonized tools and databases to collect and store data related to quality traits.

Interviews and documentary analysis confirm these trends in terms of enhancement and introduction of these practices. For instance, biophysical and biochemical analyses (i.e. texture, color, water absorption capacity, sensory characteristics) are now used beyond the development and testing phase by a great majority of food labs in RTBfoods partner organizations.

Key recommandations:

1. Consolidate and communicate results on low, medium and high throughput phenotyping methods and tools for quality traits
2. Prioritize and demonstrate
    - For the coming phase, prioritize, through multidisciplinary consultation, a limited number of SOPs for quality traits assessment which results have high probability to be integrated in breeding pipelines.
    - For the coming phase, identify a limited set of traits for which SOP and thresholds can be determined and validated.
3. Integrate and institutionalize
    - Build on the actual use of quality-related data to develop procedures and standards in relation with stage-gate approach and adapted to different organizational models.

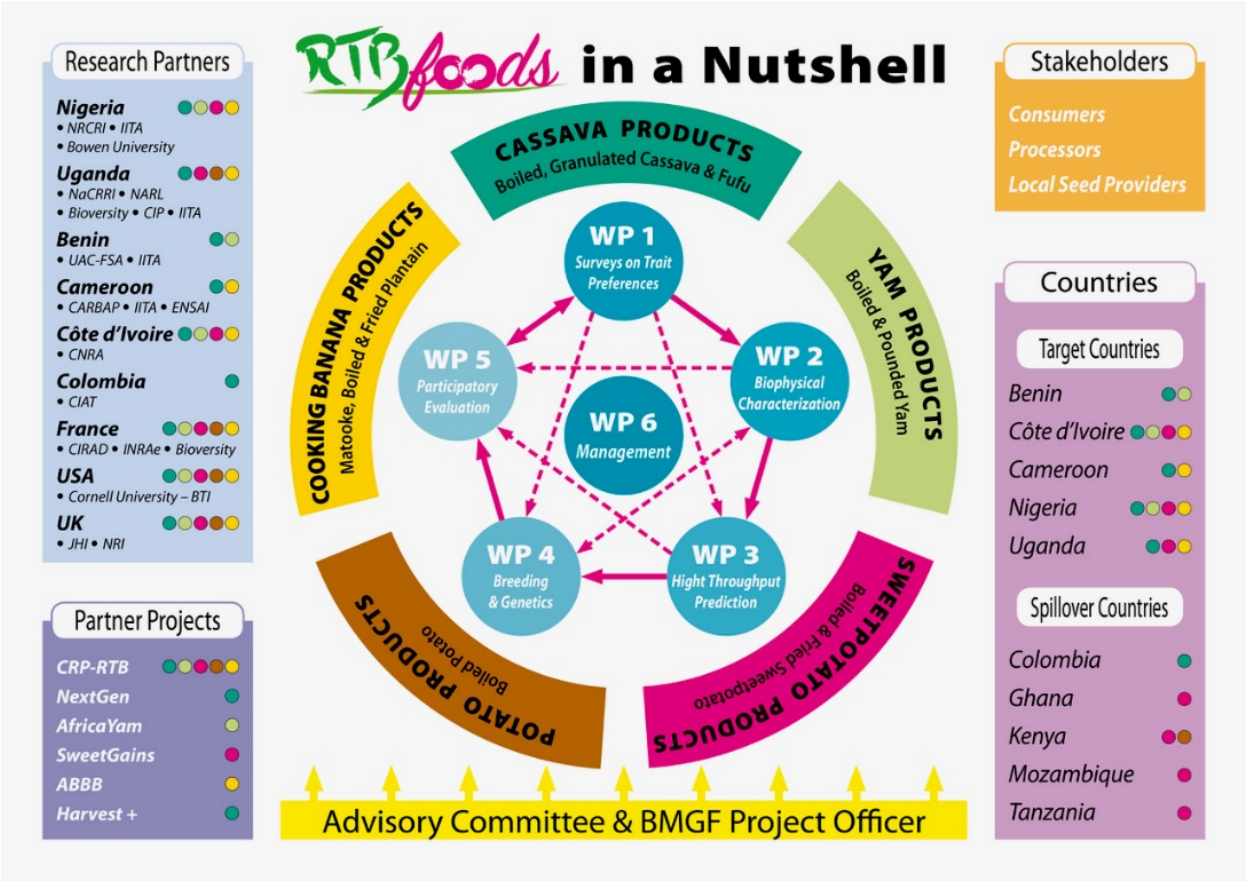
Key Words: outcome harvesting, impact, participatory, survey, breeding program, evaluation, lessons learnt.

1 EXECUTIVE SUMMARY

1.1 The project

The RTBfoods project (Breeding RTB Products for End User Preferences) aims to pinpoint the **quality traits that determine the adoption of new root, tuber and banana (RTB) varieties** developed by breeders in five African countries (Benin, Cameroon, Côte d'Ivoire, Nigeria, Uganda).

Image 1 : Summary of the RTBfoods project



The project started at the end of the year **2017 and was implemented during 5 years**. RTBfoods focuses on five work packages (WP):

- WP1 looks at **socioeconomic aspects and identifies the criteria** that determine whether a variety is adopted or rejected. Aspects linked to gender (role of women and children in decision-making, impact of variety traits on drudgery, etc.) are closely looked at;
- WP2 establishes the link between the above users' criteria and the **biophysical properties** of different varieties **and the underlying biochemical drivers**;
- WP3 builds on CIRAD's expertise in terms of near-infrared spectroscopy analysis (NIRS) to develop tools to **predict the quality traits** of the new varieties;
- WP4 investigates the **genetic components of quality traits** and assesses the impact of the environment on their variability;
- WP5 assesses whether new varieties developed by breeders and released have better matched users' quality criteria[1] .

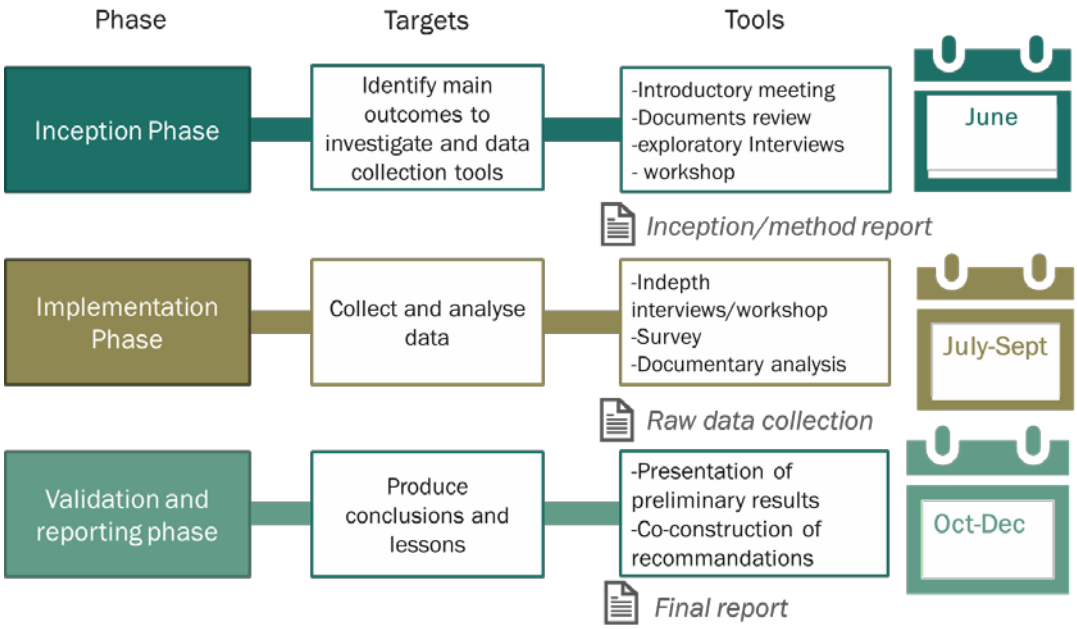
[1] *Source: https://rtbfoods.cirad.fr/project/rtbfoods-description*

1.2 The evaluation method

This project was evaluated between June and December 2022 by a mixed evaluation team with one external evaluator from Quadrant Conseil, one evaluator from Cirad ImpresS team and the RTBfoods project manager for monitoring, evaluation and learning (MEL).

An outcome harvesting method was deployed with the following data collection tools.

Diagram 1 : the 3 phases of this evaluation



1.3 Main results

The project was implemented in a relatively conducive context where other initiatives and projects were supporting breeding programs led by international and national research centers in better integrating quality and post-harvesting related traits as part of their breeding objectives.

An uneven level of awareness about the importance of integrating user needs and preferences in breeding programs existed across crops and countries when the project started. Participants in the evaluation acknowledged that **RTBfoods made significant contributions to make mindsets change and interdisciplinary collaboration capacities and practices evolve** across the diversity of situations. These intermediary outcomes were not explicitly defined in the project results framework. Nevertheless, participants agree on the fact that they were instrumental for the achievement of the expected outcomes and will contribute to the sustainability of the results achieved.

- The evaluation found that the project **strengthened partners' capacities for the development and use** of:
- **participatory and gender-sensitive methods and tools** to understand user needs and preferences;
- **food product profiles**;
- **standard operating procedures** to assess quality traits;
- a set **of low, medium and high-throughput phenotyping protocols** to measure and predicts quality traits. Both technical and equipment capacities were strengthened in this field;
- **harmonized tools and databases** to collect and store data related to quality traits.

These changes in capacities are acknowledged both by partners that were already using these methods, tools and technical equipment before RTBfoods and by partners that started using them thanks to the project. It is to note that, with reference to the set of practices examined and based on the results of the survey, a percentage comprised **between 20 and 37% of the respondents stated that they started a new practice thanks to RTBfoods** (more details are presented in the table below).

Table 1: Evolution of practices before and after the RTBfoods project (survey results)

Practice	Used before RTBfoods	Started with RTBfoods
Data collection on user needs and preferences	41%	21%
Food product profiles development	37%	36%
Use of laboratory SOPs to assess quality traits	39%	37%
Use of MTP or HTTP to predict quality traits	35%	20%
Use of standardized methods and tools for data management	54%	24%
Integration of information on user preferred traits in decision-making processes along breeding pipelines	26%	26%
Assessment of RTB clones/varieties against traits linked to food product profiles	30%	37%

Interviews and documentary analysis confirm these trends in terms of enhancement and introduction of these practices. For instance, **biophysical and biochemical analyses** (i.e. texture, color, water absorption capacity, sensory characteristics) are now used beyond the development and testing phase by a **great majority of food labs in RTBfoods partner organizations**.

The **progress with near-infrared spectroscopy analysis (NIRS) has been slower than expected** due to an underestimation of the amount of data, time and financial resources needed to validate calibration curves and build prediction models. Use of NIRS in cassava and yam breeding programs has been documented for some traits (i.e. dry matter, starch, total carotenoids, cooking time, proteins). **Building on previous results on calibration curves for these traits,** RTBfoods served as platform for knowledge sharing and capacity development.

Progress on the **use of information generated on quality traits in decision making** processes has been noted. Though, the **limited access to validated and affordable HTP and MTP protocols** for assessing quality traits has been one of the main limiting factors for integrating selection criteria related to quality traits in decision-making processes in the **early stages** of the breeding programs. In the **later stage** of the breeding pipelines, when the number of samples to be assessed is less important, **the integration of new traits as part of the selection scheme has been observed** and information obtained through sensory analysis, textural and colorimetric analysis used.

Table 2: Synthetic table of outcomes

Main achievements	Ongoing work or weaknesses
Adoption of methodology to collect data on users preferred traits	
How to collect data on user-preferred traits systematically and ethically was **one of the main fields of capacities strengthening** **Many knowledge gaps were addressed** on consumer preferences	**Challenges remain on interpreting** and using the amount of data collected Challenges for future use due to **insufficient resources (financial and skills) and time** foreseen.
Use of product profiles	
Capacities strengthened for the development of food product profiles **Insights and information used before publication** of the food product profiles	Use of profiles limited due to their **delayed publication** Challenges for future use linked with their **continuous evolution, data and resources needed for updating**

Main achievements	Ongoing work or weaknesses
Use of SOP to assess quality traits	
Capacities significantly strengthened (technical skills and equipment) to continue adapt and develop SOPs **Proven use** of some of the SOPs beyond the development and testing phase	Discrepancies between project ambitions vs available resources Challenges for future use: **equipment maintenance costs, need for thresholds**
Use of HTP or MTP technologies and protocols	
Capacities moderately strengthened (technical skills and equipment) to continue adapt and develop HTTP (NIRS) **Proven use** of some of the HTTP beyond the development and testing phase	Data and time needed to **validate calibration curves and build prediction models** were underestimated Challenges for future use, mainly linked to **cost of the method and maintenance plans**
Use of Standardized method and tools to manage data	
Capacities strengthened in using standardized methods and tools for data management (large datasets; common matrices; new tools)	Efforts still needed to ensure **quality of data** uploaded. Uneven use of the tools Challenges for future use mostly linked to **comparability and data access**
Integration of users preferred traits in breeding pipelines	
Quality traits mainstreamed in target product profile templates (OneCG) **Proven use** of data generated on quality traits in decision-making, in particular in advanced breeding stages.	**Assessment approaches and thresholds** are still the limiting factor to integrate them in product profiles and in selection process (in particular in the early stages)
Enhanced interdisciplinary dialogue	
First collaboration with other disciplines for about 1/3 of the respondents. **Improved capacities to collaborate** for more than 80% of respondents Led to collaboration outside the project for a majority	In some cases, **data prepared by food scientists are still not fit for use** for breeders Different level of collaboration depending on crops / teams
Enhanced network of institutes and projects on RTBs across countries	
Almost all members have **expanded their professional network at a national, regional and international level** **Led to new collaboration or strengthened collaborations**	Degree of collaboration depending on organization Remaining difficulties due to different types of funding across organization

1.4 Key recommendations

- Consolidate and communicate results on low, medium and high throughput phenotyping methods and tools for quality traits
    - Before the project closing, focus on making broadly accessible through scientific and training materials the results on methods and tools validated or close to validation.
    - Before the project closing, work on the accessibility of all the data that could be further used to calibrate and validate assessment methods and tools
- Prioritize and demonstrate
    - Before the project closing, further document the cases where information on quality traits has integrated in decision-making processes in breeding programs.
    - For the coming phase, prioritize, through multidisciplinary consultation, a limited number of SOPs for quality traits assessment which results have high probability to be integrated in breeding pipelines.
    - For the coming phase, identify a limited set of traits for which SOP and thresholds can be determined and validated.
- Integrate and institutionalize
    - Build on the actual use of quality-related data to develop procedures and standards in relation with stage-gate approach and adapted to different organizational models.
    - Generate data on effort / time needed to develop/adapt low, medium and high-throughput protocols for new traits to better plan the investment needed.

2 EVALUATION METHODOLOGY

2.1 Using evaluation to foster a culture of impact

This study has been funded by Cirad as part of the institutional efforts to promote the use of evaluation as reflexive and learning-oriented exercise to generate knowledge and learn lessons on the contributions and contribution pathways of research to societal impacts.

Cirad is establishing an internal mechanism that will provide methodological and financial support for the implementation of two types of evaluations: impact evaluations (focusing on long-term innovation processes and their impacts with the ImpresS ex post method) and outcome evaluations (focusing on outcomes emerging during or just after the implementation of an intervention).

The internal mechanism will be officially launched in 2023. The RTBfoods evaluation constitutes a first pilot for this mechanism.

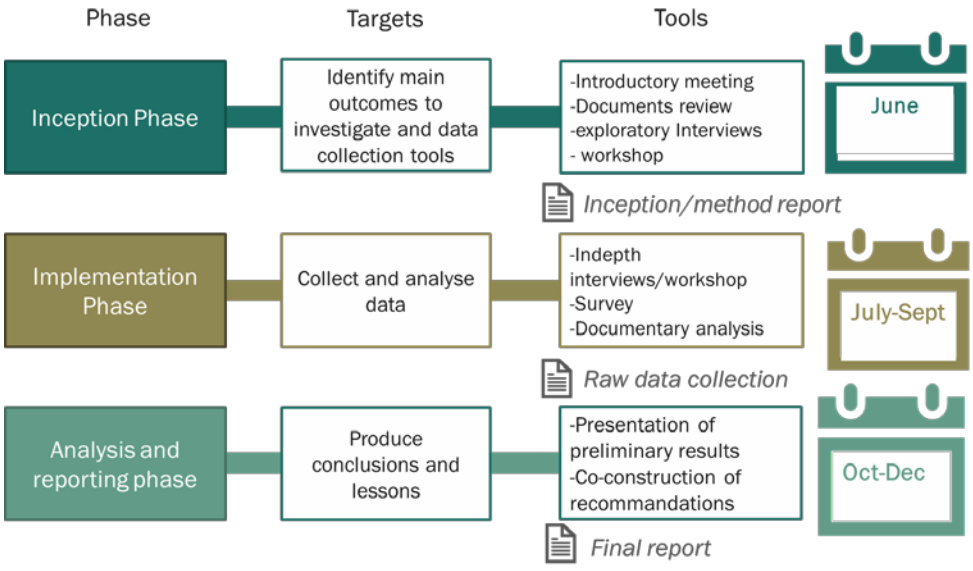
2.2 Method and tools deployed

This evaluation deployed an **outcome harvesting method** that was adapted to the context of the project[2].

The evaluation team decided to deploy Outcome Harvesting in 3 phases:

- **The inception phase**, regrouping the 3 first steps of the method:
  - Design of the harvest (place, time, duration, tools, participants),
  - Harvesting of the first testimonies on perceived/experienced outcomes,
  - Formulation of key outcomes identified with project stakeholders;
- **The implementation phase,** dedicated to substantiating and validating the key outcomes identified and prioritized;
- **The analysis and reporting phase:** regrouping the last two steps of the method:
  - Analysis of the final set of revised outcomes i;
  - Sharing the findings and supporting their use.

Diagram 2 : the 3 phases of this evaluation



[2] *The reasons driving the methodological choices for this evaluation can be consulted in the Inception note.*

2.2.1 The inception phase

The inception phase consisted in:

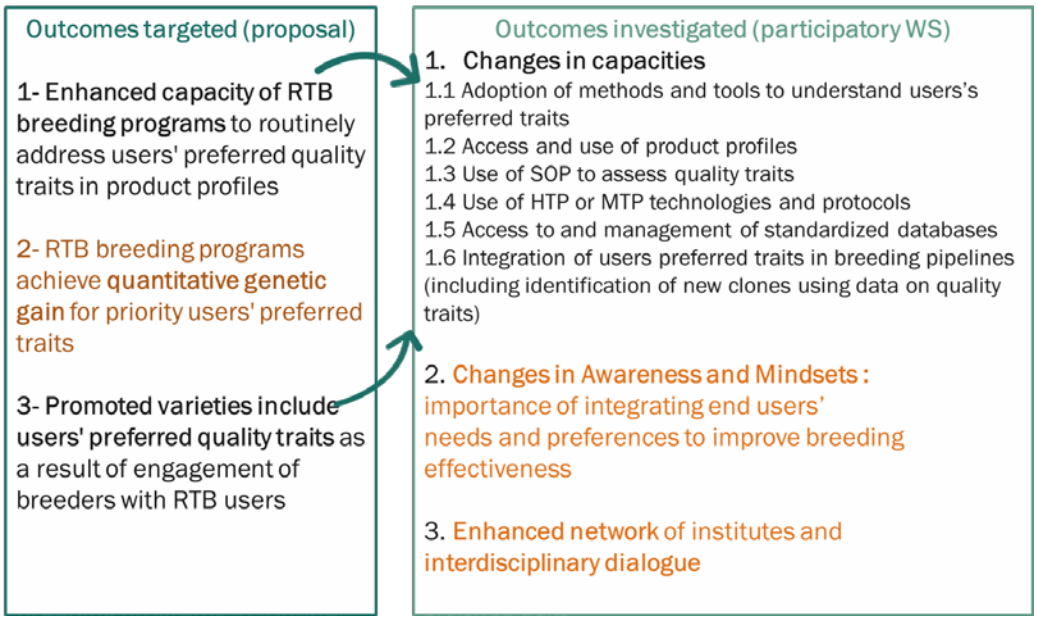
- **11 exploratory interviews** conducted with scientists who are actively involved in the RTBfoods consortium (see list of interviews in annex p 41);
- **A participatory workshop organised with 3 groups of 12 to 13 participants** (total of 37 participants) to "harvest" the main outcomes experienced by the participants, and that they could directly or in-directly relate to the existence of the RTBfoods project and its outputs.

The analytic part of the inception phase was performed in a participatory way with participants and dedicated to:

- Regroup outcomes mentioned by stakeholders in common categories;
- Select and prioritize categories to be investigated more in-depth during the data collection phase;
- Identify approaches and tools for data collection and analysis in order to substantiate the different outcomes.

After the workshop, the evaluation team compared the outcomes initially targeted by the project and mentioned in the proposal, with the ones highlighted during the exploratory interviews and the participatory workshop. It appeared that one outcome initially targeted would not be investigated (see text in brown in image 1 below) since it could not yet be observed. 2 un-expected categories of outcomes were included in the list of initial outcomes to be investigated (see text in orange below) as they were repeatedly mentioned by interviewees and workshop participants.

Image 2 : Matching between targeted outcomes mentioned in the project proposal (on the left) and outcomes mentioned by participants during the inception phase and selected for further investigation during the implementation phase (on the right)



2.2.2 The implementation phase

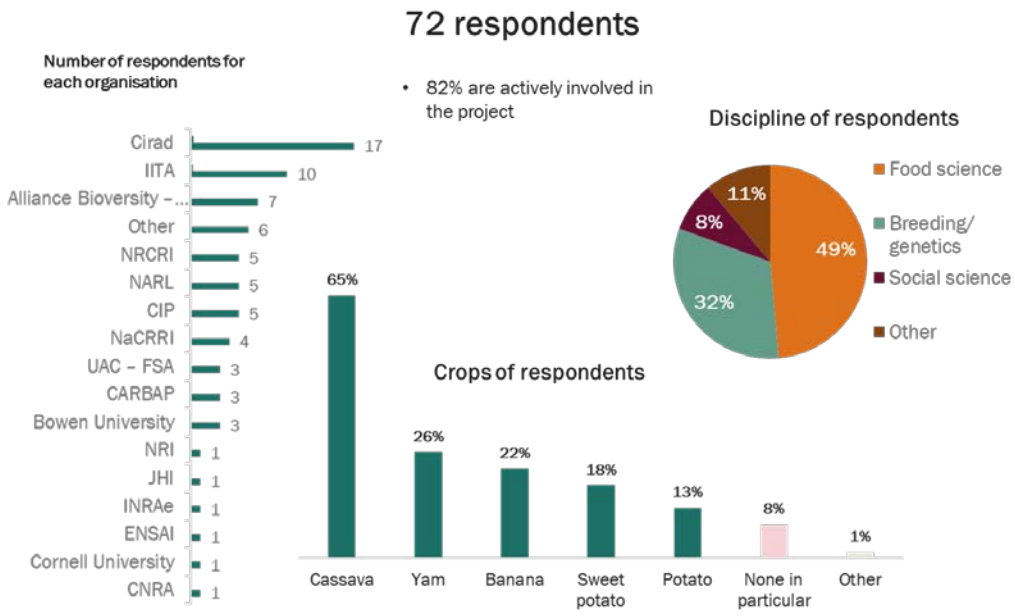
The implementation phase - or substantiative phase to use the terminology of the outcome harvesting approach - deployed different data collection tools.

The online survey

An online survey was deployed for 3 weeks in September 2022. This survey systematically investigated the main outcomes identified during the inception phase. It was sent to approximately 200 individuals.

The profile of respondents covers a diversity of disciplines, organizations, and crops.

Figure 1 : Profile of the survey respondents



This survey collected answers from a diversity of practitioners, characteristics of the respondent represent accurately the characteristics of the yet, the scientific community involved in the RTBfoods project (diversity of disciplines and crops). As the participation in the survey was voluntary, not all institutes are represented to the extent of their real participation in the project. It is to be noted that the participation of respondents that were not directly involved in the project consortium has also been recorded.

The majority of respondents are professionals working on cassava. It reflects their important proportion within the project consortium.

Interview and workshop

16 bilateral interviews have been conducted in Nigeria, during the 2022 annual meetings of two sister projects on cassava (NextGen Cassava) and yam (AfricaYam). The list of people interviewed is in annex p 41. These interviews were conducted by evaluation team members from Cirad and analysed by the external evaluator[3]. The matrix of analysis of these interviews is included in the annex

[3] *Due to both late financial proposal by BMGF for field mission funding and the lack of availability of the external consultant on the opportunities of data collection, the external consultant could not participate to data collection on site.*

separate folder. These interviews also contributed to the overrepresentation of professional working on cassava in the data collected.

One participatory workshop was held with 15 participants from NextGen Cassava project in order to investigate their perception of the collaboration with RTBfoods and how they appreciate the use of concepts, approaches and tools developed by / with RTBfoods scientists.

Evaluation team members from Cirad attended the 2022 annual meetings of NextGen Cassava and AfricaYam. It was an opportunity to directly observe if and how concepts, approaches and tools developed by / with RTBfoods were mentioned in the presentations made by colleagues from these two sister projects.

Documentary analysis

A systematic inquiry was conducted through a documentary analysis. The aim of this analysis was to identify evidence of the investigated outcomes in key RTBfoods project documents or sisters project documents. The list of documents analysed can be consulted in annex p **Erreur ! Signet non défini.**.

This analysis was conducted by the evaluation team on an Excel sheet to record the proof of outcome and link it to the documents analysed.

2.2.3 The validation and reporting phase

The validation and reporting phase were conducted by the external evaluator and the Cirad evaluation team following a common matrix (see in inception note).

The intermediary results of the outcome evaluation and an initial set of recommendations were presented in November 2022 during the RTBfoods 2022 annual meeting, in Nairobi (Kenya). After the presentation, feedbacks from consortium participants were collected.

2.3 Main considerations on methodology

2.3.1 Main assets

The **participatory dimension** of the outcome harvesting approach is one of its main assets. It allowed the evaluation team to reach conclusions on the main outcomes investigated that were deemed relevant by the RTBfoods consortium members with limited time and budget.

Associating a diversity of stakeholders from the inception phase of the evaluation enabled the evaluation team both to **confirm that most of the main targeted outcomes were relevant to be investigated** and provided details on how to document these outcomes.

Moreover, inception participatory workshops were useful to **identify intermediary outcomes that were not explicitly targeted by the project but that constituted some of the main changes** that project stakeholders observed across organizations. These outcomes are particularly interesting as they are **means to enhance changes in capacities and practices**. For instance, interdisciplinarity is a necessary first step to develop food product profiles but the development of food product profiles contributes to convince stakeholders of the added value of interdisciplinarity. Such intermediary outcomes, for instance the improved capacity to collaborate across disciplines, crops and organizations constitute a valuable asset for the design and the implementation of future initiatives.

The implementation phase benefitted from a **survey designed to investigate both outcomes and specific contributions of the project to these outcomes**. Although the response rate was not as high as expected, this data collection tool enabled the evaluation team to confirm, document and harvest other more specific examples on the outcomes already identified in the inception phase.

The successive workshops and meeting events organized during the inception phase, the implementation phase and the validation phase were **key participatory time to reinforce and**

adjust the approach adopted by the evaluation team and better refine its conclusions and recommendations.

In brief, thanks to its participatory dimension, this approach allows to produce interesting results in a context of limited availability of data (no-baseline, no specific monitoring on outcomes).

2.3.2 Main limits

Given the scope of this project, the resource allocated to the evaluation **could not allow the evaluation team to thoroughly investigate each outcome, in all organizations, and for each crop**. Therefore, statements on outcomes are mostly generic. Yet, all of them were validated by the main project stakeholders and the documentary analysis.

Moreover, due to planning and organizational difficulties, the external evaluator could not conduct the investigations on one of the sites identified (Nigeria). Yet, this task was conducted by one member of the Cirad ImpresS team who was not part of the RTBfoods project and could conduct the interviews and facilitate the workshop as an external evaluator. The external evaluator however helped preparing protocols for data collection on sites.

At last, the lack of baseline data available for this evaluation did not allow the evaluation team to rigorously assess the evolution of practices and had to rely exclusively on stakeholders' statements and observations.

3 MAIN RESULTS

3.1 Project context and objectives

Roots, tubers and bananas (RTB)[4] are essential crops both for consumption and market in the humid tropics of Sub-Saharan Africa (SSA)[5] and **their importance is expected to be growing in the coming decades**[6]. International and national agricultural research centres have been working on developing modern varieties which adoption rate in SSA countries is low (for the crop group, 32.9% of the area cultivated with modern varieties) if compared with other crop groups, i.e. cereals or legumes.

High yield and disease resistances are the main traits that have been initially targeted by breeding programs. Consumer-preferred traits linked with organoleptic properties, processing abilities, cultural preferences have been found to be a driver of adoption and the limited attention given to these traits in breeding program concours in explaining the limited adoption rates observed (Thiele et al. 2021).

Recent initiatives show that, across crop groups and specifically for RTB crops, CGIAR research centres in collaboration with national agricultural centres are engaged in **reforming their breeding programs to better integrate quality and post-harvesting related traits as part of their breeding objectives** (See Table 1).

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[4] This includes bananas and plantains, cassava, potatoes, sweetpotatoes and yams.

[5] Thiele, G., Dufour, D., Vernier, P., Mwanga, R.O.M., Parker, M.L., Schulte Geldermann, E., Teeken, B., Wossen, T., Gotor, E., Kikulwe, E., Tufan, H., Sinelle, S., Kouakou, A.M., Friedmann, M., Polar, V. and Hershey, C. (2021), A review of varietal change in roots, tubers and bananas: consumer preferences and other drivers of adoption and implications for breeding. Int. J. Food Sci. Technol., 56: 1076-1092. https://doi.org/10.1111/ijfs.14684

[6] International Food Policy Research Institute (IFPRI), 2022, "IMPACT Projections of Total Production (Million Metric Tons) With and Without Climate Change: Extended Commodity-Level Results for 2022 GFPR Table 2A", https://doi.org/10.7910/DVN/IRUH4G

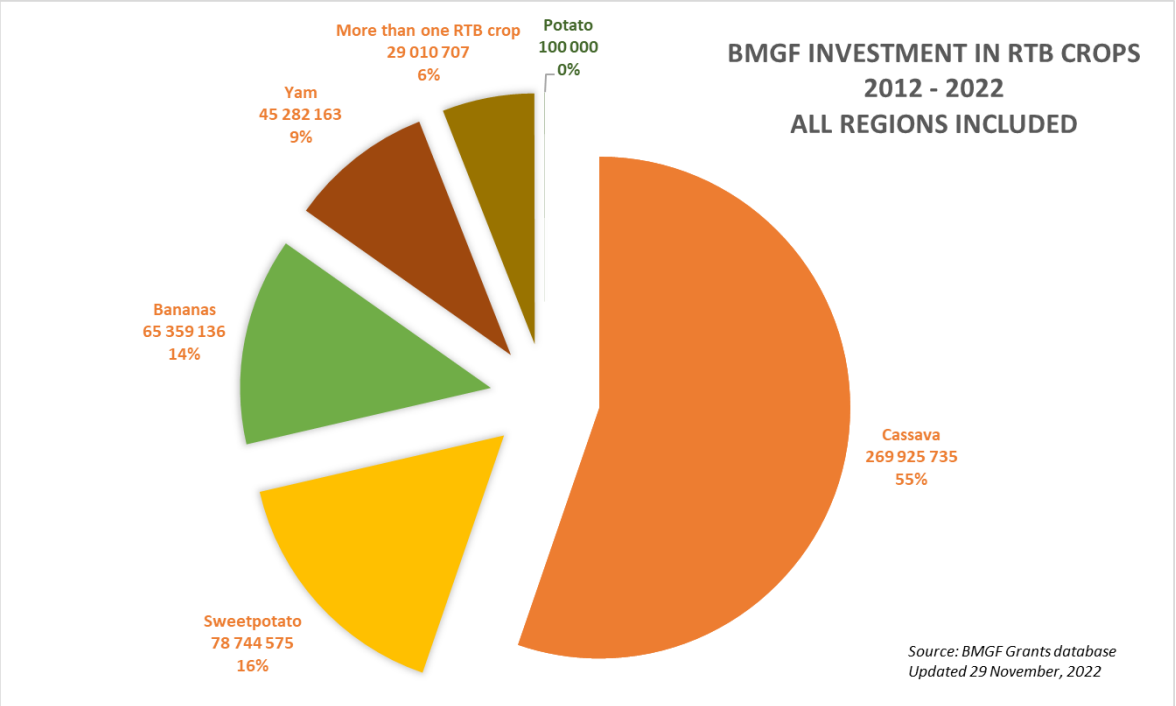
Table 3 : Recent initiatives conducted by CGIAR and national agricultural centres

Program / Initiative	Starting date
CGIAR Research Programs targeting specific crops/agri-food systems (including CRP on RTB)	Phase I – 2012 Phase II – 2017
CGIAR Excellence in Breeding (EiB) Platform	2017
Initiative on "Crops to End Hunger"	2019
Accelerated Breeding Initiative (ABI): Meeting farmers' needs with nutritious, climate-resilient crops	2022
Market Intelligence and Product Profiling Initiative	2022

The CGIAR website presenting the initiative on "Crops to End Hunger" summarizes the new direction sought for the breeding programs: *"One part of this challenge is for breeding to modernize in terms of its **objectives beyond pure yield gain** – to address the expanding demand for improved varieties to meet **biotic** and **abiotic stresses**, such as climate change and environmental degradation, and to include a wider set of **nutritional** and **market traits**, as well as traits relevant to both end-users and value chains, which would increase the adoption rate of newly-bred varieties."*[7]

RTB crops research and development initiatives have being significantly supported by the Bill and Melinda Gates Foundation across the globe in the same period (2012 – 2022) (see Figure 2) with crop breeding investment dedicated to bananas (Breeding Better Bananas), cassava (NextGen Cassava), sweetpotato (SASHA, SweetGains) and yam (AfricaYam).

Figure 2 : BMGF investment (USD) in RTB crops 2012-2022



In this context, the RTBfoods project aimed at building or reinforcing the capacities of project participants by designing, developing, testing, adapting and validating standard operating procedures, methods and tools to enhance the inclusion of users' needs and preferred quality trait throughout breeding decision and selection process. An interdisciplinary approach was promoted

[7] *https://www.cgiar.org/excellence-breeding-platform/crops-to-end-hunger/*

across almost all the work packages. It was expected that researchers with different disciplinary background, thanks to their participation in project activities and in the production of different outputs, will have routinely adopted/adapted their practices at different stages of their breeding activities. These changes were primarily expected at the consortium level and some spillover effects, through the collaboration with sister projects and other initiatives, were considered.

3.1.1 Outcomes investigated

Three categories of outcomes were investigated in this evaluation. All the outcomes refer to partners implementing RTB breeding programs. Partners are primarily members of the RTBfoods consortium but spill-over effects were considered. The three categories are as follows:

- **Changes in capacities and practices.** This constituted the principal focus of the investigation and included:
  - Adoption of methods and tools to understand users' preferred traits;
  - Access and use of product profiles;
  - Use of standard operating procedures (SOP) to assess quality traits;
  - Use of high-throughput phenotyping (HTP) or mid-throughput phenotyping (MTP) technologies and protocols;
  - Access to and management of standardized databases;
  - Integration of users' preferred traits in breeding pipelines (including identification of new clones using data on quality traits).
- **Changes in awareness and mindsets** on the importance of integrating users' needs and preferences to improve breeding effectiveness;
- **Enhanced network of institutes and interdisciplinary dialogue**.

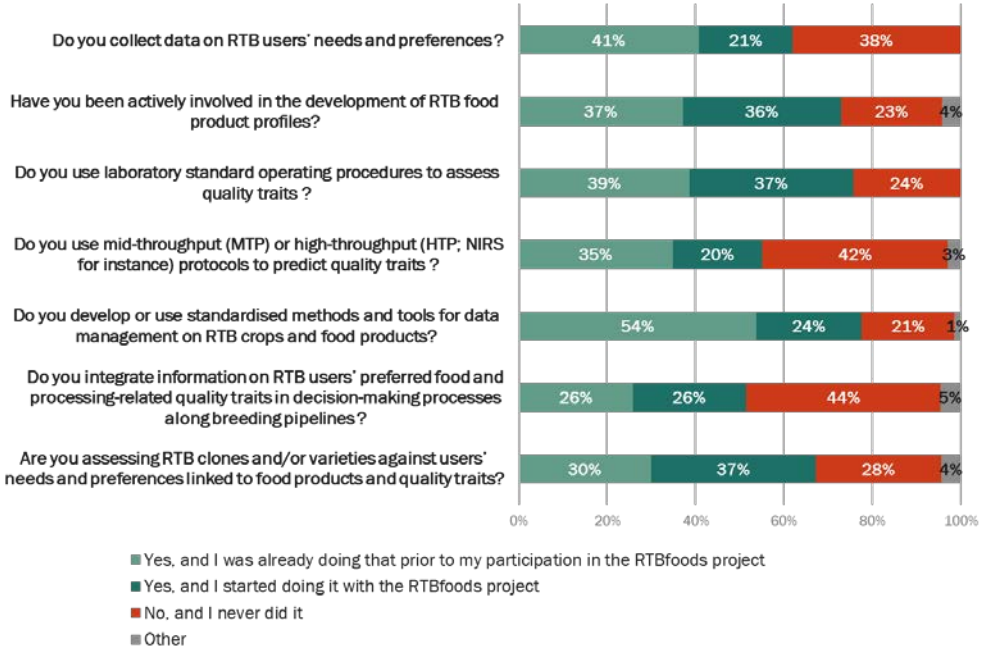
This document presents the main findings from the cross analysis of data collection tools deployed throughout the evaluation.

3.2 Changes in capacities and practices targeted by the project

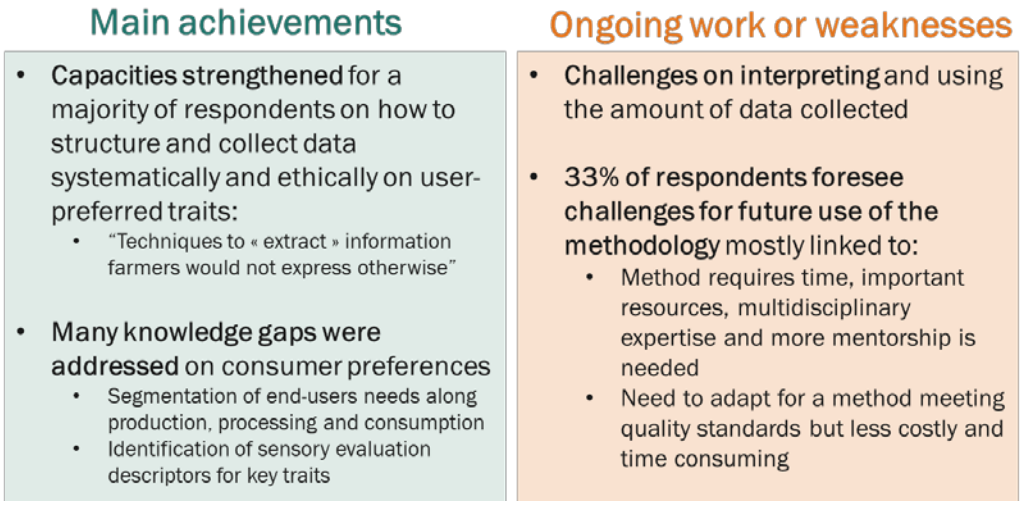
Changes in practices were investigated with different data collection tools both qualitatively and quantitatively. A broad overview of the results from the survey (see figure below) shows that, on average, 60% of the respondents are using the practices investigated. It is important to note that a portion of the respondents, more or less significant depending on each practice, was already using these practices prior to the RTBfoods project (light green bar in the figure) while others started using these practices thanks to the RTBfoods project (dark green bar in the figure).

The following analysis investigates the extent of the adoption of each practice.

Figure 3 : Overview of the changes in practices in the domains invested by RTBfoods activities (source survey n= 70)



3.2.1 Adoption of methods and tools to understand users' preferred traits



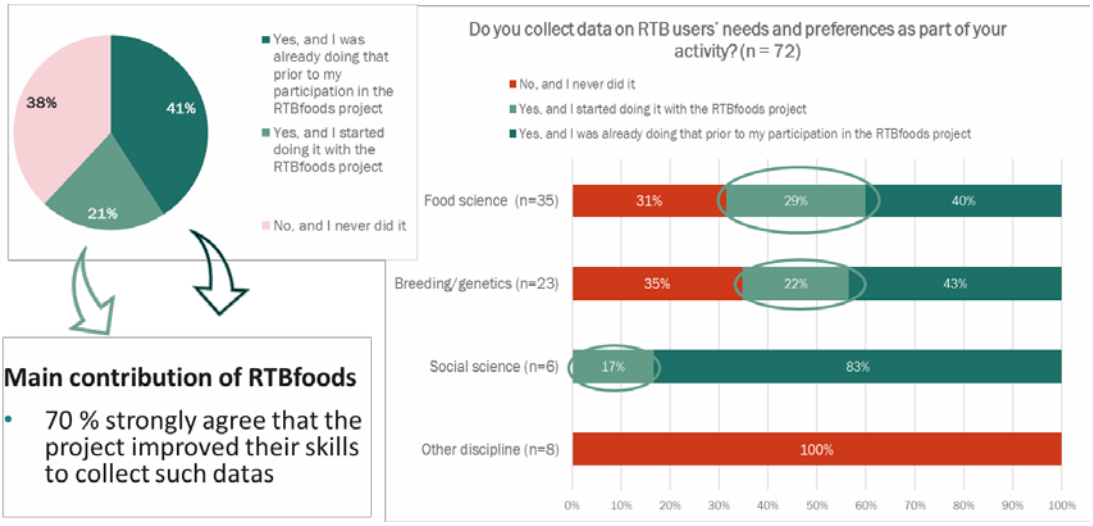
Main achievements

This outcome mainly resulted from **activities conducted in RTBfoods work package 1**: « Understanding the drivers of trait preferences and the development of multi-user RTB product profiles ». The main outputs contributing to this outcome were the **specific methodologies and related guidance to collect data on users preferred traits**[8]. Gender dimensions were integrated in the methodologies developed both at the data collection, data analysis and prioritization of preferred traits stages.

[8] *https://rtbfoods.cirad.fr/deliverables/scientific-cross-cutting-activities/methodological-manuals-training-material/surveys-on-trait-preferences ,a stepwise methodology was developed and peer-reviewed in an international journal (IJFST). https://doi.org/10.1111/ijfs.14680*

According to the survey conducted and on average, **40% of respondents already collected data on users' needs and preferences before RTBfoods.** When looking at the disciplinary background, almost all social scientists and about 40% of food scientists and breeders were already collecting this type of data. About **20% of them all started collecting such data within the project**.

Figure 4 : Results from survey to the question: "Do you collect data on RTB users' needs and preferences as part of your activity?"



The main project contribution here was in terms of capacity development. Indeed, a large majority of respondents **(70%)** has improved their skills in conducting such activities thanks to RTBfoods. **This is the most significant improvement of skills acknowledged by respondents across all the domains investigated through the online survey**. The implementation of RTBfoods survey methodologies strengthened partners' capacities **to systematically structure and ethically collect data on users' preferred traits**. Capacities developed mentioned by stakeholders are mainly:

- More expertise in data collection through focus group discussions and processor or consumer interviews;
- Learning of techniques to « extract » information farmers would not express otherwise;
- Structuring a segmentation of end-users' needs along the product chain (e.g. production, processing and consumption steps);
- Identifying gender-responsive quality traits.

Many knowledge gaps were addressed regarding consumers preferences and patterns. For instance, sensory descriptors were defined and main traits of interest for different users identified. Yet, according to different respondents, the amount of data to be collected using these methodologies was over-dimensioned compared to the real capacity of RTBfoods consortium members (budget, time, skills in data processing and management).

Analysis of sister project annual reports confirms that both the methods and tools as well as the results of the studies on users' preferences were used.

NextGen Cassava acknowledges the positive collaboration with RTBfoods during the transition from phase 1 to phase 2 where the Survey Division[9] was established and also while implementing the phase 2 activities.

We used outputs from RTBfoods and CMS studies to inform our trait selection for 1000Minds and TRICOT, ensuring integration of current knowledge on product quality traits and preferences to guide

[9] *Survey Division oversees country specific studies on user typologies, associated trait preferences and descriptors, relative and economic weights of traits and large scale on farm performance evaluation.* https://www.nextgencassava.org/survey/

this work. (NextGen Cassava annual report 2020)

In Tanzania, we do not plan to undertake 1000Minds, but we have instead applied the RTBfoods gendered food mapping tool (Forsythe et al, 2020). A total of 404 respondents across Lake and Eastern Zone participated in interviews, focus groups and market interviews. We will leverage learning from this research as we have deployed RTBfoods results in Tanzania and Uganda, triangulating with TRICOT results in Year 3. (NextGen Cassava annual report 2020)

Evidence of the use of RTBfoods results in yam and sweetpotato breeding projects is also available in SASHA, SweetGains and AfricaYam annual reports.

… gender-responsive consumer profiles and acceptance studies are underway. This is in preparation to extend similar work in Southern Africa, where such studies have never been conducted. In-depth work on boiled sweetpotato already done in Uganda (under RTBfoods) will be extended to Mozambique, where the work will focus on boiled and fried sweetpotato. (SweetGains annual report 2020)

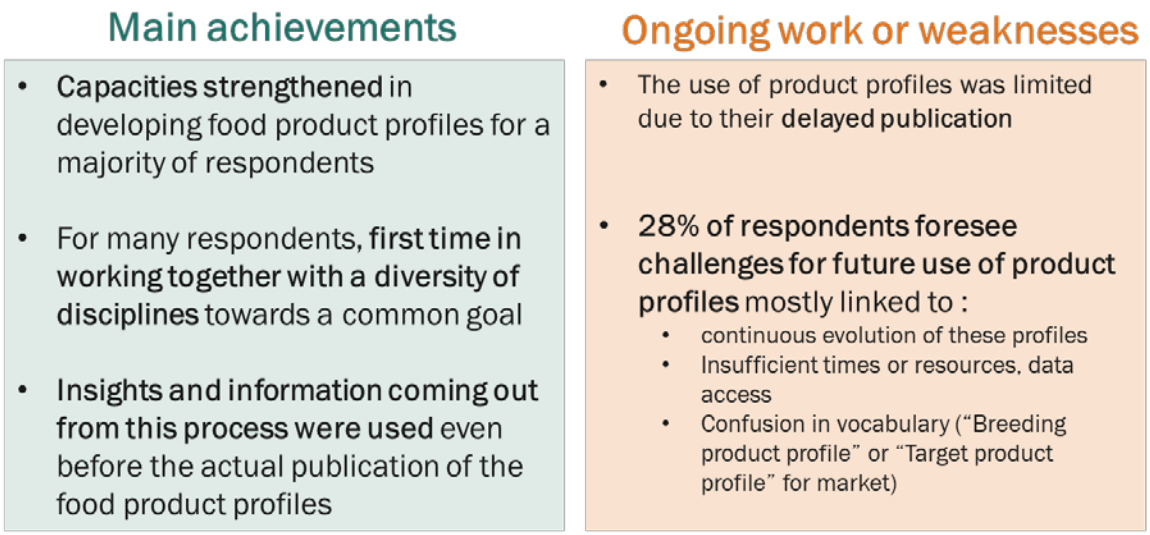
Ongoing work or challenges

According to the survey 33% of respondents foresee challenges related to collecting data on users' needs and preferences in future interventions. The method developed is so far seen as very resource demanding both in terms of human and financial resources and difficult to conduct as such without specific funding or tutoring. Hence main challenges identified for the future are:

- Insufficient time or resources available;
- Difficulties to maintain reliable communication with end-user groups & correct interpretation of data collected;
- Need for multidisciplinary expertise to conduct such enquiry that is not available in some organisations;
- Need for more mentorship / framework to keep conducting these surveys with these standards.

Finally, a majority of people consulted recognize the skills developed but ask for either a simplification or consolidation of the method developed through WP1.

3.2.2 Access and use of product profiles



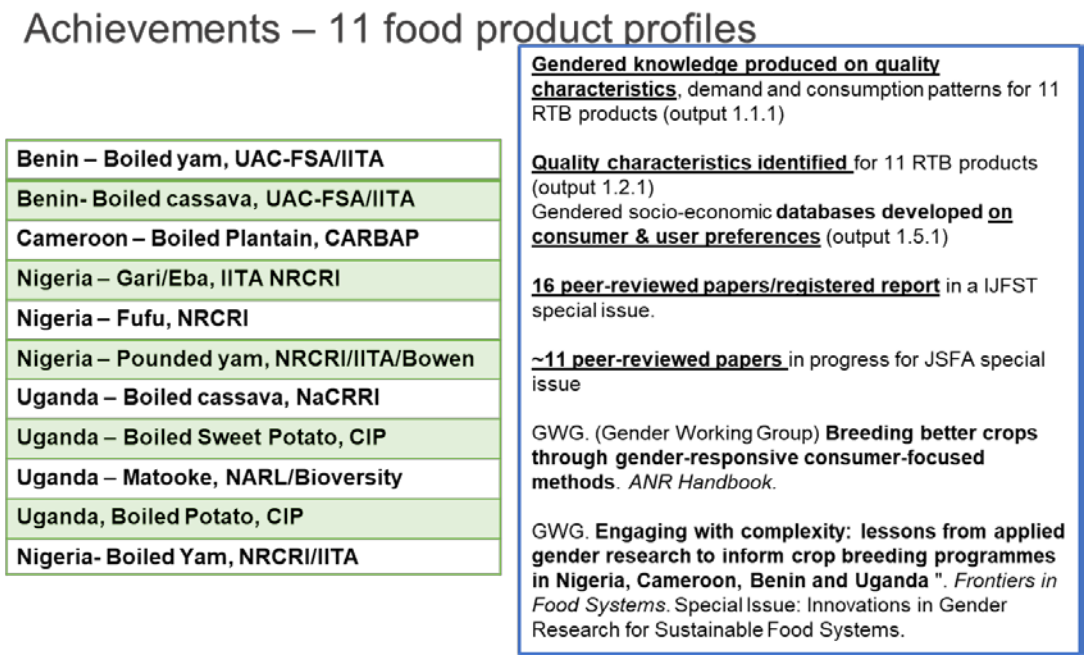
Main achievements

Activities in work package 1 also aimed at delivering Food product profiles synthesizing and making available a list of raw, processing and cooked characteristics for the main food products identified. Gender dimensions were strongly included in this work package and, for the development of product profiles, collaborations established with CRP RTB and Gender and Breeding Initiative for the use and adaptation of G+ Product Profile[10].

The synergy among different projects and initiatives around the fostering of gender-responsive breeding is well illustrated by Polar et al. (2022)[11] for the cassava case. Since 2016, the NextGen Cassava project initiated a partnership with the GREAT initiative and the project staff, including biological and social scientists, participated in capacity development activities on gender and breeding. In 2016, the project recruited an interdisciplinary postdoctoral fellow specializing in gender who performed gender analysis on data already collected (e.g. Cassava Monitoring Study (CMS) - IITA - 2500 households) and introduced more systematically gender analysis into participatory varietal evaluation methods. The gender analysis using the CMS data and research carried out under the NextGen Cassava and RTBfoods project found that traits such as “easy to peel” and other traits related to “food product quality” (e.g. colour and texture of the dough-like products) were particularly important and especially for women wo are strongly involved in processing and trading. The convergence of findings and support from all these initiatives urged the breeding programs in IITA and NRCRI to further explore user preferences related to processing and food quality.

To date 11 food product profiles have been completed (see image below).

Image 3 : Extract from RTBfoods annual meeting 2022



According to the survey 75% of the respondents were actively involved in the development of food product profiles and all disciplines were evenly represented (see Figure 6). Some interviewees identified this activity as a demonstration of the relevance of such interdisciplinary approach.

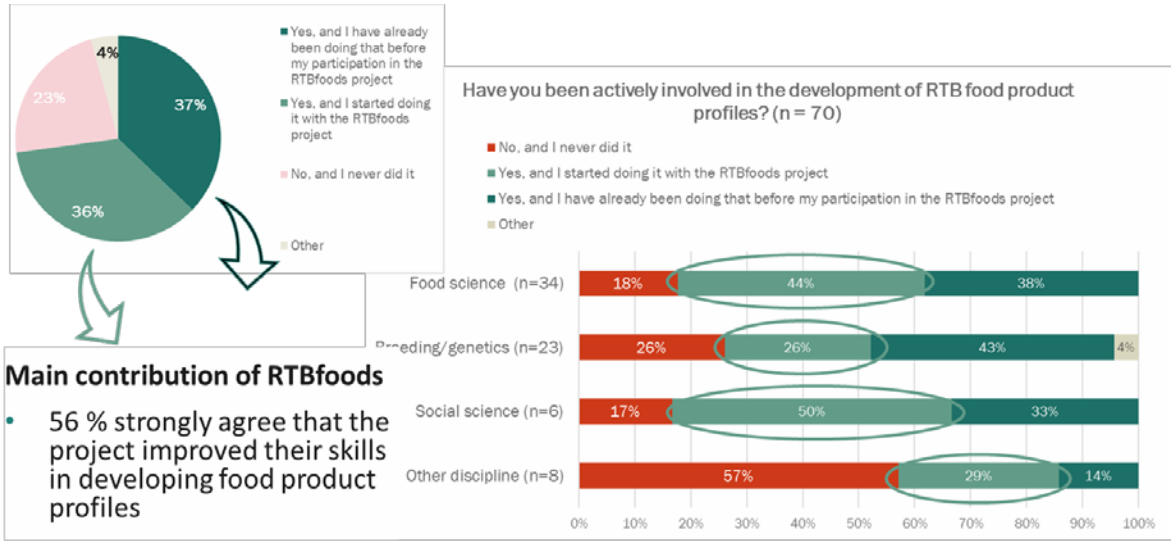
[10] https://rtbfoods.cirad.fr/deliverables/scientific-cross-cutting-activities/gender-mainstreaming-lessons-learnt

[11] *Polar, V. et al. (2022). Building Demand-Led and Gender-Responsive Breeding Programs. In: Thiele, G., Friedmann, M., Campos, H., Polar, V., Bentley, J.W. (eds) Root, Tuber and Banana Food System Innovations. Springer, Cham.* https://doi.org/10.1007/978-3-030-92022-7_16

This activity was new for almost half of food scientists and social scientists. Overall, half of all professionals that participated actively to the development of food product profiles have increased their skills in conducting this activity:

« RTBfoods project has enhanced the understanding of the product profile in terms of standardized procedures in preparations, data collection and analysis. »

Figure 5 : Results from survey to the question: « Have you been actively involved in the development of RTB food product profiles?



Yet, more than half of the respondents criticized the way this activity was conducted. In particular, as the results of this work package (WP) were supposed to orient the activities in WP2 and WP3, the delay in the identification and prioritization of characteristics / traits to be assessed has been penalizing the work of other teams.

The fact that the public version of food product profiles was only recently published (2021 or 2022) also limited their use in breeding programs. Nevertheless, learnings from and use of the data on users' preferences and linked traits took place before the finalisation of the food product profiles and activities on standard operating procedures to assess identified traits started before the final publications.

The project contribution in integrating quality traits in RTB product profiles is largely confirmed by interviewees and documentary analysis in cassava, yam and sweetpotato:

The program has defined market segments and developed product profiles for the market segments. We also conducted yam trait elicitation surveys in four countries, Nigeria, Benin, Ghana, and Cote d'Ivoire, in 2021 to link breeding objectives with product profile and market segment. (AfricaYam annual report 2021)

In Uganda, the Excellence in Breeding's (EiB) 1000minds survey by AbacusBio and RTBfoods investments have provided the basis for refining breeding objectives to focus on robustness, productivity, and cooking quality traits. Good progress was made toward breeding for the key cooking quality traits for boiled sweetpotato, prioritized from the gendered food mapping from the BMGF's RTBfoods investment in Uganda. The prioritized sensory traits included firmness, mealiness, sweetness, aroma, and non-fibrousness. (SweetGains annual report 2021)

It is to note that, since 2017, main funders and breeding initiatives across CGIAR have been increasingly pushing for the formalization of product profiles (clearly targeting specific market segments and user needs) as key step towards the optimization of breeding programs.

Ongoing work or challenges

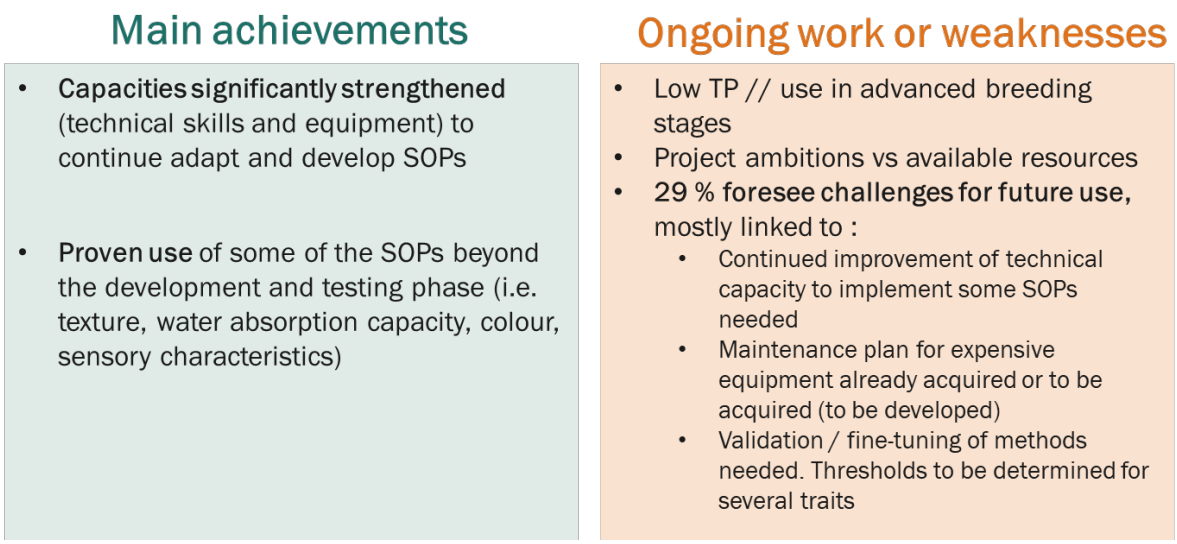
Respondents foresee challenges related to the use of existing RTB food product profiles in future interventions, mainly due to the lack of solid, rapid and affordable instrumental protocol for each trait for their prediction to be used in breeding process and the lack of thresholds established to use them as discriminatory criteria in the selection process. One respondent explains:

> *"The current product profiles can be sharper with respect to the list of traits and their desired expression levels that meet end-user requirements. The profiles can be further differentiated to match specific requirements of end-users with a particular need or preference as preferences are clustered as function of various requirements. Not all traits in product profiles have a solid instrumental protocol for their prediction or insufficient accuracy or capacity to serve breeding programs that like to breed for them."*

Other challenges identified are:

- continuous evolution of these profiles and insufficient times or resources to update them, as well as difficult access to data;
- confusion in vocabulary (food product profile vs. Breeding product profile or Target product profile for market).

3.2.3 Use of standard operating procedures to assess quality traits



Main achievements

The development of standard operating procedures is the result of activities conducted under work package two: "Biophysical Characterization of Quality Trait" which consisted in translating users' preferences identified through WP1 activities into measurable traits.

Three types of SOPs were established

- **On sensory testing -** 8 laboratories were set up with trained panel and are operational since 2019, 10 SOPs are finalised and 3 tutorials were released[12].
- **On biophysical analysis (mainly on colour and texture) -** 10 SOPs were finalized for all the products: pounded and boiled yam, boiled cassava, eba, fufu, matooke and boiled

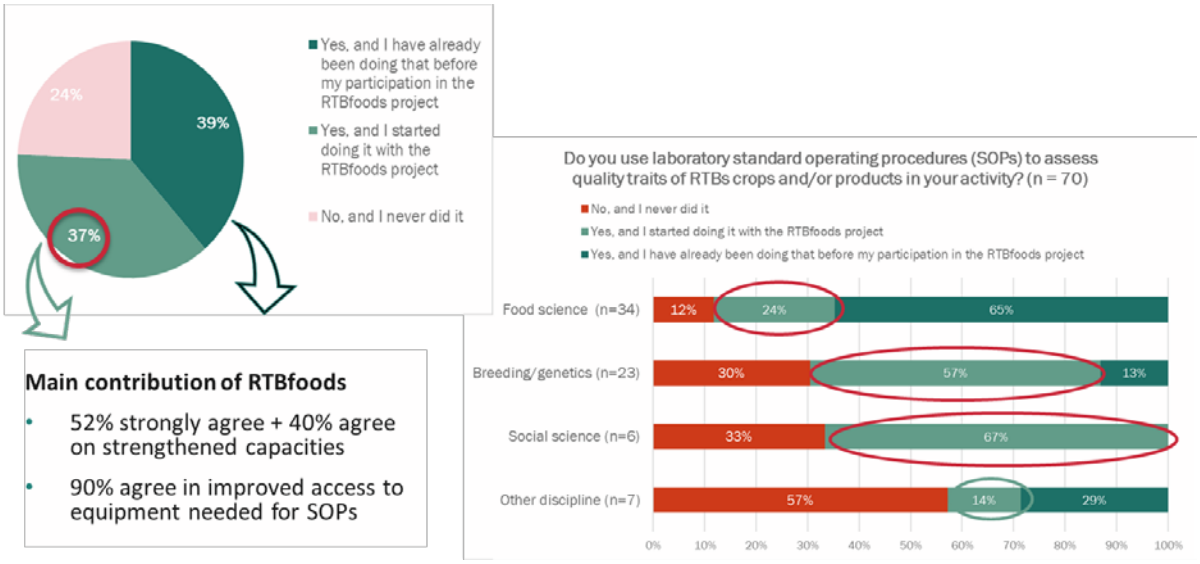
[12] *Source: RTBfoods annual meeting 2022*

sweetpotato.

- **On biochemical analysis -** 11 SOPs were finalized for all the products: for all products (5), specific for yam and plantain (2) and sweet potato (4). Moreover, 4 videos about cell wall components and pectin analyses were released.

According to our survey, amongst practitioners using SOPs to assess quality traits almost half of them started with RTBfoods. Yet, we observe high heterogeneity across disciplines. Only 24% of food scientists started using SOP with this project while around 60% of breeders and social scientists started with this project (see Figure 6). The high percentages of breeders and social scientists stating that they started using SOPs is rather difficult to interpret based on the comments provided in the survey and on the elements collected through the interviews. Indeed, breeders in the cassava and yam teams tested some of the SOPs on their own and social scientists have been involved in participatory testing with processors and consumers, though the percentage is higher than expected.

Figure 6 : Results from survey to the question: "Do you use laboratory standard operating procedures to assess quality traits of RTBs crops and/or products in your activity?"



The project greatly contributed to improve access to equipment of laboratories to conduct these techniques as well as strengthening skills to implement such SOPs (see Image 4).

As one respondent summarized:

> *"Before the RTBfoods project use of instrumentation and adherence to SoPs were not commonplace. Now this has been reinforced and integrated."*

SOPs are now used beyond the development and testing phase (i.e. texture, colour, water absorption capacity, sensory characteristics) by a great majority of food labs in RTBfoods partner organisations. The organization of sensorial testing has been also developed by other partners.

There is not always evidence that the use of SOPs in food labs and the results produced are systematically being used within breeding processes. Yet, and as part of the collaboration with NextGen Cassava, results on texture analysis and sensory testing are being used by CIAT, NaCRRI and NRCRI to support breeding decisions; IITA and NRCRI used SOP for the sample preparation, texture and sensory analysis as part of a genome-wide association study. Also, in 2022, both instrumental and sensory SOPs for assessing boiled and pounded yam quality were applied in AfricaYam on 60 genebank accessions, 100 clones included in preliminary performance trials (PPT) and 16 clones included in national performance trials (NPT) in Nigeria (*AfricaYam annual report 2022*). The year before, sensory evaluation/consumer acceptability of boiled and pounded yam from local and released varieties was carried out in Ghana and in Nigeria where on 86 farmer white

Guinea yam varieties collected from different yam production zones were assessed as well as elite clones included in multilocation field trials (*AfricaYam annual report 2021*).

The *SweetGains annual report 2020* summarizes as follows the collaboration with RTBfoods:

> *Several SOPs have been developed for the determination of cooking time, texture analysis, and sensory profiling in WP2. A kitchen is being installed at NaCRRI in Namulonge in order to cook sweetpotato and other RTB crops. This is where the breeding activities are organized and screening of sweetpotato clones is mostly done. An RTB sensory panel was trained at NARL in Kawanda. A lexicon for boiled sweetpotato is now available, and work is underway to enter it into the global crop ontology. Validation is in progress to link the sensory profiling with the texture SOP and cooking time. Other traits contributing to the texture are also being studies such as cell wall composition, pectin content, beta-amylase activity, and gelatinization temperature in collaboration with the different partners in RTBfoods (CIRAD, CIAT, and JHI). (SweetGains annual report 2020)*

One year later, the spill over effect of the Ugandan activities in Mozambique is also documented:

> *Using the Uganda experiences in the RTBfoods investment, a sensory panel of 15 people was trained and set up in Maputo, Mozambique, under the guidance of RTBfoods protocols. … SOPs for texture analysis were developed for Mozambique, and training on texture analysis was successfully conducted. The texture analyser was installed and all kitchen utensils for texture analysis are in place (SweetGains annual report 2021).*

Ongoing work or challenges

Despite the progress made, respondents still foresee challenges for future use of SOP mostly linked to:

- Need to continued improvement of technical capacity to implement some SOPs
- Validation / fine-tuning / development of methods is still needed;
- Maintenance plan need to be developed for expensive equipment already acquired or to be acquired;
- Thresholds are to be determined for several traits;
- Uncertainty on continued priority and funding allocated to quality trait assessment.

3.2.4 Use of HTP or MTP technologies and protocols

Main achievements	Ongoing work or weaknesses

• **Capacities moderately strengthened** (technical skills and equipment) to continue adapt and develop HTTP (NIRS)
• **Proven use** of some of the HTTP beyond the development and testing phase
	• NIRS is considered as the main technique with HT capacities
	• Project ambitions vs available resources
	  ◦ Data and time needed to validate calibration curves and build prediction models were underestimated
	• **35 % foresee challenges for future use,** mostly linked to :
	  ◦ Continued improvement of technical capacity to use HTPP needed
	  ◦ Viability (cost) of the method (stationary vs handheld), uncertainty on funding
	  ◦ Calibration curves and thresholds to be determined for several traits

Main achievements

Work package 3 aimed at developing high-throughput phenotyping (mainly near-infrared spectroscopy analysis - NIRS) and mid-throughput phenotyping technologies and protocols that can be applied in national and international breeding programs to assess quality traits.

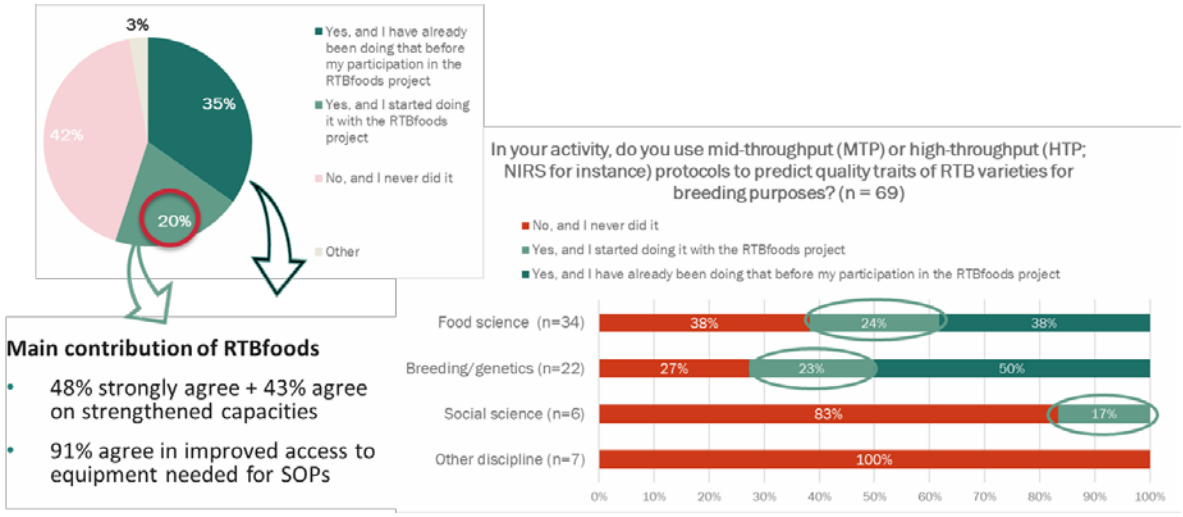
To date 18 SOP were validated[13]:

- 7 SOPs using NIRS on fresh cassava (intact/blended);
- 3 SOPs using NIRS on fresh yam (intact/blended);
- 1 SOP using NIRS on fufu;
- 1 SOP using NIRS on milled and unmilled gari
- 2 SOPs using hyper-spectral images (HSI) on fresh intact RTB
- 3 SOPs using numeric camera for colour characterization of RTB
- 1 SOP using microscope camera for RTB starch grain size and shape

According to our survey around 60% of food scientists and breeders are using MTP or HTP in their breeding activities and about 25% started using them with RTBfoods.

[13] *Source: RTBfoods Annual Meeting 2022*

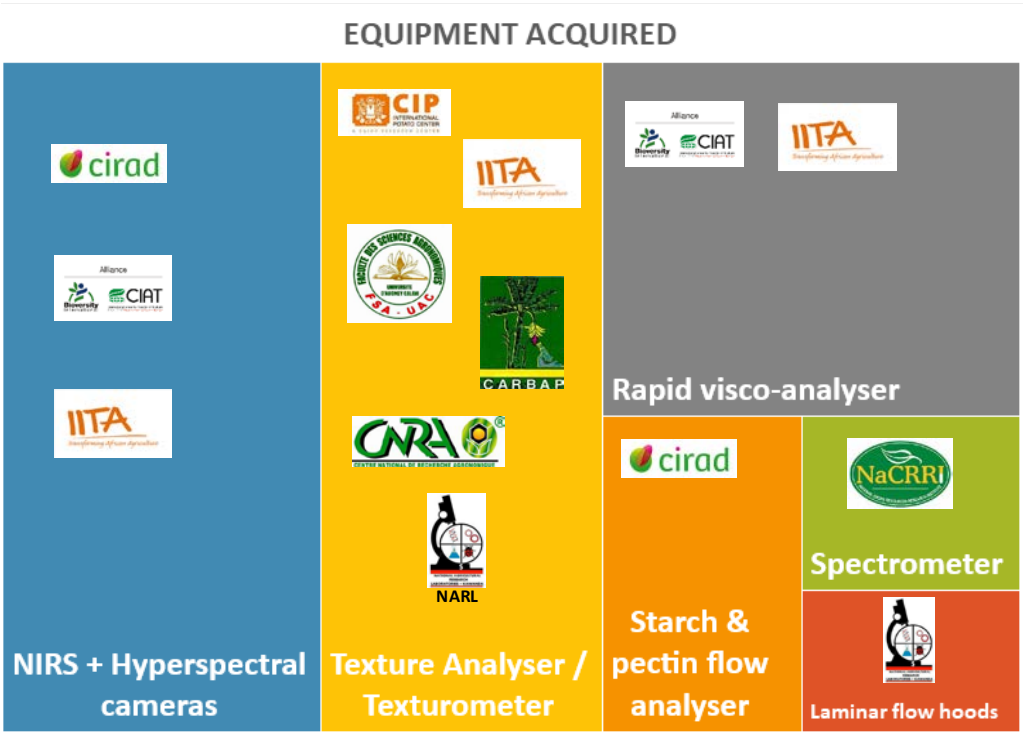
Figure 7 : Results from survey to the question: "In your activity, do you use mid-throughput (MTP) or high-throughput (HTP-NIRS for instance) protocols to predict quality traits of RTB varieties for breeding purpose?"



According to the respondents, RTBfoods contributed to strengthening capacities to assess quality traits with these techniques both in technical and equipment capacities.

The main equipment acquired both for low, mid and high-throughput protocols and the budget allocated are represented in the image below.

Image 4 : Budget allocated to the purchase of major equipment (over 5K USD) by partner institutes in the RTBfoods project.



During our investigations proven use of some HTTP beyond the development and testing phase was identified for the following crop x trait x partner combinations:

- Cassava: on dry matter, starch, total carotenoids, *cooking quality (cooking time) on boiled cassava*) – by CIAT, IITA, NaCRRI, NRCRI and in collaboration with NextGen project. It is important to notice that research activities needed for establishing calibration curves for these

traits had been realized before RTBfoods[14] and that the project served as platform to allow for knowledge sharing and capacity development.

- Yam: on dry matter, starch, protein, sugar by INRAE Guadeloupe, IITA, NRCRI in collaboration with AfricaYam.

In the framework of two other projects (RTBfoods and Cavalbio), NIRS technology was developed in Guadeloupe in collaboration with the Food processing Laboratory of INRA. The CNRA was also involved in the work through Emmanuel Ehounou, a PhD student, who was financed by RTBfoods, to work on the NIRS technology in Guadeloupe.

The NIRS methodology is now operational and can be used to determinate the dry matter content, starch content, sugar content, protein content and hardness of D. alata accessions. So far, 84 hybrids from population A (74F x Kabusa) were phenotyped out of a total of 108 genotyped by GBS. Analysis on population B is ongoing. First results obtained for population A are presented in CIRAD year 5 report (AfricaYam annual report 2020).

Ongoing work or challenges

According to respondents and interviewees these are among the most fragile outcomes in terms of sustainability beyond the project. The project did not reach its final objectives on this work package mainly due to the underestimation of the amount of data, time and financial resources needed to validate calibration curves and build prediction models.

Actual use of HTPP and MTP is still limited by the absence of validated acceptability thresholds for each studied trait. The research work that will allow combining consumers' perceptions with instrumental measurements should happen in the last year of the project (RTBfoods annual report 2021).

Respondents identified **challenges for completing these tasks and for the future use of NIRS.**

The main challenges identified are:

- The need for further capacity development activities for all the partners to use HTPP and the uncertainty on continued priority and funding allocated to this area;
- The cost-effectiveness of the method including the study of the alternative equipment that may be used (stationary vs handheld material);
- The need for maintenance plans for expensive equipment already acquired or to be acquired;
- Uncertainty on continued collaboration among partners beyond the project if other funds are not secured;
- The number of traits for which calibration curves and thresholds have to be determined.

[14] *Cf. Ikeogu UN, Davrieux F, Dufour D, Ceballos H, Egesi CN, et al. (2017) Rapid analyses of dry matter content and carotenoids in fresh cassava roots using a portable visible and near infrared spectrometer (Vis/NIRS). PLOS ONE 12(12): e0188918. https://doi.org/10.1371/journal.pone.0188918*

3.2.5 Access to and management of standardized databases

Main achievements	Ongoing work or weaknesses

• **Capacities strengthened** in using standardized methods and tools for data management :
  • Skills to handle large number of materials and analyse them
  • Use of common matrices for sensorial and consumers testing
  • Use of new tools (CassavaBase, Fieldbook)
• Standardization of data collection and safe storage and accessibility of harmonized datasets for staff within the same breeding program and across RTB crops
	• Efforts still needed to ensure quality of data uploaded in DB – Protocols and HR for data management not established at the beginning of the project
	• Uneven use of the tools
	• **Challenges for future use** mostly linked to :
	  • Comparability and access to data from all partners
	  • Data storage, resources and technical capacity
	  • Adapting and merging new data/tools/technology to existing practices

Main achievements

Another key category of activities conducted under Work Package 2 aimed at improving data set and data management of users' preferences and quality traits. The main outputs produced were:

- Cleaning of Sensory & Textural Datasets;
- Open Access for all project documentation & datasets in repositories;
- Ontology & Trait Dictionaries Development for Breedbases;
- Adaptation of Breedbase Structure to receive Phenotyping Data on Quality;
- Upload of formatted NIR spectral data.

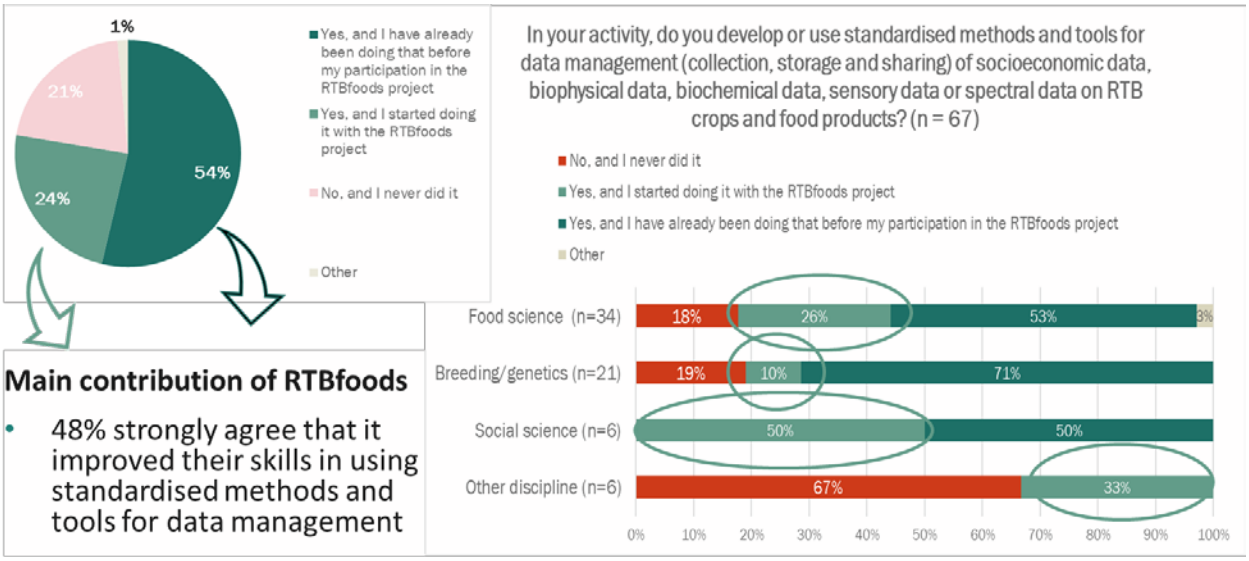
According to our survey, more than ¾ of the respondents develop or use standardized methods and tools for data management and **¼ started with the RTBfoods project**. These "new" users are to be found mostly amongst social scientists and food scientists (see Figure 8Figure 8). Amongst practitioners that already developed standardized methods for data management and new users, half improved their skill with RTBfoods. Some already well advanced in this area did not recognize specific improvements:

> *"We are already strong in this area. Some progress was made but we already were making good progress on this so this project didn't really advance this much".*

For teams less experienced the project introduced new tools such as common data bases, and the use of fieldbook:

> *"Application of xl-stat was good for me to learn. Easy to apply (…). This area could be strengthened further in future project implementation activities"*
>
> *"I learned how to use, and started using Breedbase"*
>
> *"Fieldbook and barcode have been introduced to the quality team."*

Figure 8 : Answer to the question "In your activity, do you develop or use standardized methods and tools for data management? "



The main skills developed with the RTBfoods projects are:

- Knowledge and understanding of **common standards in order to share data** between organizations and research teams;
- Capacities to **handle large number of samples** and analyse them;
- Use of **common matrices for sensorial and consumers testing**;
- The use of **common crop databases** (e.g. CassavaBase, YamBase, etc.).
    - This is a great asset for standardization of data collection and safe storage and accessibility of harmonized datasets for staff within the same breeding program and, potentially, across programs (no evidence of cross-program data exchange was found during the implementation phase). Synergies across organizations and projects for the development and adaptation of BreedBase structures and tools were identified and appreciated.

"Onset of RTBfoods got us using cassavabase, which is a robust data ecosystem. New demands (e.g. spectra data, trait ontologies) arising from RTBfoods are being swiftly addressed by the developers"

"The collection and storage of data was become more formal/standardized, using tools such as field books and cassava base. This ensures/helps with long-term availability of data. This is thanks to requirement from the start of the RTBfoods project to have a data management strategy"

CassavaBase continues to benefit from the synergies between the other projects that are using BreedBase backends, including MusaBase, YamBase and SweetpotatoBase. All the improvements implemented on the behalf of these projects are also automatically available in CassavaBase. While these projects benefit tremendously from the infrastructure created for CassavaBase that was applied to their projects, the benefits go both ways. In the last couple of years, new features inspired by these programs included a Mixed Model Tool, improved crossing schemes, and the post composition of traits. In addition, drone image analysis – a major feature - was incorporated from other projects. A project that was a major driver of the NIRS integration is the RTBfoods project (NextGen Cassava annual report 2021).

Yet, the use of this tool is still to be strengthened (completeness and quality of the data), in particular for data on quality traits.

Ongoing work or challenges

Albeit these improvements these skills are unevenly developed amongst organization and practitioners. The lack of definition of protocols and human resources dedicated to this task at the beginning of the project lead some organizations to underestimate the cost and capacity needed to assure the quality of data management. A data manager had to be recruited by the project management unit in 2021 to support all the work packages in cleaning and preparing their data for an upload into BreedBase and/or other public repositories.

¼ of respondents to the survey foresee challenges or bottlenecks in using standardized methods and tools for data management in the future, mostly linked to:

- Comparability and access to data from all partners;
- Data storage capacities;
- The difficulty of adapting and merging new data/tools/technology to existing practices;

"The integration of quality data into existing databases is an important challenge, database structures must be developed to accommodate sensory, textural or even socio-economic data." (interview)

BreedBase features still need to be adapted to the specificities of laboratory data mostly generated with replicates, on raw, processed and cooked samples coming from one single root/tuber harvested from a registered trial. To do so, ontologies for most of those specific traits still need to be developed by RTBfoods food scientists supported by ontology experts (RTBfoods annual report 2021).

- Insufficient resources to sustain this activity;
- Lack of technical capacity within the organization.

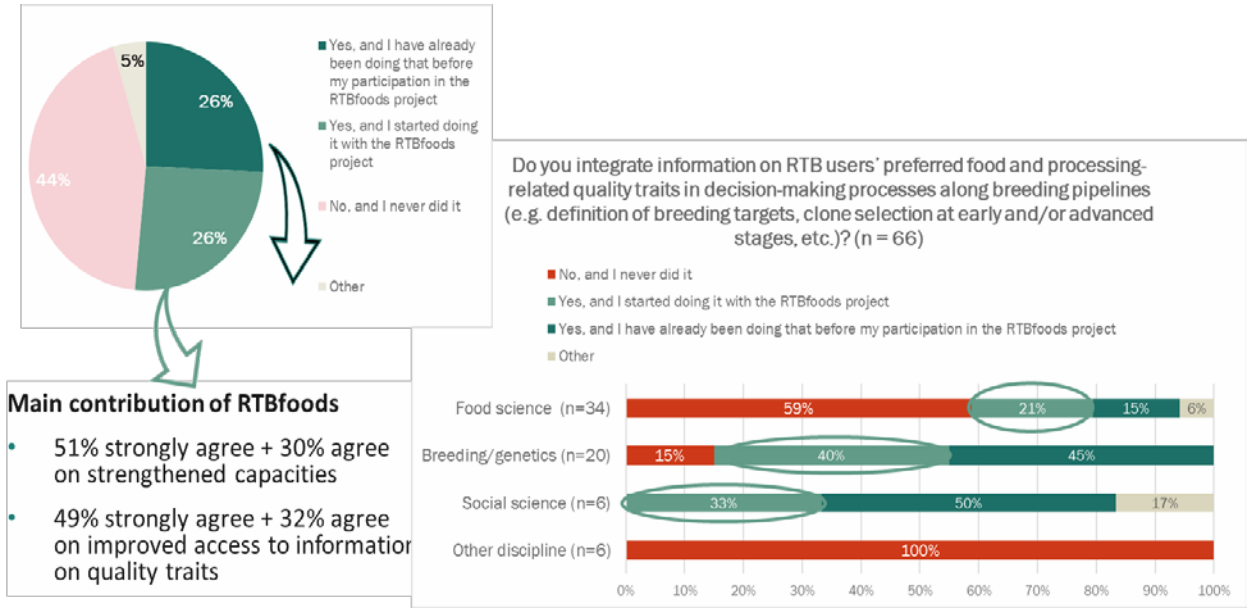
3.2.6 Integration of users' preferred traits in breeding pipelines

Main achievements	Ongoing work or weaknesses
• **Quality traits mainstreamed in target product profile templates (OneCG)** • RTBfoods contribution acknowledged but … CRPs, EiB, OneCG reform, Breeding projects … are leading this change • **Proven use** of data generated on quality traits in decision-making, in particular in advanced breeding stages.	• Traits linked with user preferences are better known, assessment approaches and thresholds are still the limiting factor to integrate them in product profiles and in selection process (in particular in the early stages) • Stage-gate approach is progressively introduced in breeding programs. Product advancement meetings have been organized for cassava and yam.

Main achievements

According to our survey half of the respondents actually integrate information on users' preferred traits in decision-making processes. Although all types of disciplines answer this question, the salient result of this survey is that **40% of the breeders declare that they started integrating users' preferred trait in breeding decision making with RTBfoods** (see Figure 9).The results are quite similar for the use of these traits by breeders to assess new clones or varieties.

Figure 9 : Answers to the question: "Do you integrate information on RTB users' preferred food and processing related quality traits in decision-making processes along breeding pipelines?"



For 80% of the professionals declaring integrating users' preferred trait in breeding decision process**, RTBfoods mainly contributed to strengthen capacity to do so as well as improving access to information on quality traits.**

"Before, all what we used to do was consumer acceptability = we're working mainly with farmers in the community we are getting the consumers' perception of our genotype only. So at the very late stage of selection, when we are doing on farm when we are thinking of releasing the variety then we bring in the consumers. But now I think if we can get the food science on board at early stages of breeding, that would help a lot and will help direct us on the right path, and also make things a bit efficient for us. And, of course, collect enough data for our program".

As already mentioned, the limited access to validated and affordable HTP and MTP protocols for assessing quality traits seems to be one of the main limiting factors for integrating selection criteria related to quality traits in decision-making processes in the early stages of the breeding programs. In the late stage of the breeding pipelines, when assessing a large number of samples is not a need, the integration of new traits as part of the selection scheme has been observed. At this stage sensory analysis are the approach most frequently mentioned but textural and colorimetric analysis have also been cited.

"Consumer acceptability traits were incorporated as key selection criteria in RTB breeding practices. Inclusion of food product evaluation on UYT Trials (Uniform Yield Trials) in 3 locations".

"Breeders are now considering food quality traits in their selection indices like retting ability of fufu and softness of boiled cassava."

Improvement were also observed in the consideration of post-harvest quality as selection criterion:

"Evaluation of post-harvest quality become more central/more mainstream within breeding programs. When planning breeding trials, breeders include post-harvest quality criteria more readily for clone selection. This is made possible thanks to faster evaluation protocols such as water absorption".

Documentary analysis confirms these results. For all the crops it was possible to find at least some cases (see the synthetic table below and the complete table in annex p 49) where information on quality traits was generated and used to orient decisions along the breeding pipeline. As it emerged in the surveys and interviews, most of the cases refer to later stages of the breeding process.

Crop	**Number of cases** where quality traits were actually used for assessment and/or selection of clones included in breeding programs	**Projects and Organizations**	**Source**
Cassava	**16 cases**	NextGen Cassava CIAT, CNRA, IITA, NaCRRI, NRCRI, TARI	RTBfoods annual report 2021 NextGen Cassava annual report 2020, 2021, 2022
Cooking bananas	**4 cases**	Accelerated Breeding of Better Bananas CARBAP, CNRA, IITA, NARL/NARO	RTBfoods annual report 2021
Sweetpotato	**5 cases**	SweetGains CIP, NaCRRI	RTBfoods annual report 2021
Yam	**5 cases**	AfricaYam CIRAD, CNRA, IITA, UAC	RTBfoods annual report 2021 Dansi A., Product advancement and refinement meeting (Benin component) AfricaYam project. University of Abomey-Calavi. 2021

Ongoing work or challenges

Many challenges remain for a sustainable integration of user's need in breeding decision pipelines. These are mainly:

- Need for more systematic translation of consumer traits into relevant information for breeders (setting thresholds to use in product advancement);
- Lack of human resources and capacities to implement this interdisciplinary approach without coaching and funding from a dedicated project.

As one respondent summarize:

> *"Even though RTB breeders and food scientists are now recognising the need to work together things will not 'happen overnight' the breeding cycles are long and so probably will be ten years before results will be manifest, unless we can find ways of 'fast-tracking' improvements "*

On the positive side, it has been possible to observe, both through the participation in NextGen and AfricaYam annual meetings and the documentary analysis, that a more systematic and inclusive stage-gate approach is being progressively introduced in breeding programs and this approach is promoted/requested and supported by different funders. Product advancement meetings have been organized for cassava and yam and have involved different stakeholders and disciplinary experts. A special project, funded by BMF, is being implemented in IITA to clarify roles and responsibilities of different stakeholders at different stages (cassava) of the cassava breeding pipeline. A "RAPID" matrix - Recommends, Agrees, Performs, gives Input, Decides – is being used for this purpose.

3.3 Intermediary outcomes identified by the evaluation

The Outcome Harvesting methodology is specifically designed to identify outcomes not explicitly targeted by a project team but that were observed by a diversity of stakeholders.

Stakeholders identified three categories of outcomes that were not mentioned in the outcomes targeted by the project:

- **Increased acknowledgement of the importance of integrating end-user needs and preferences** in breeding programs and specifically the preferences, roles and contributions of women;
- **Enhanced interdisciplinary dialogue;**
- **and enhanced network** between RTBfoods consortium members.

These outcomes are transverse to all project work packages and are particularly interesting as they are at the same time:

- **Drivers for the changes in capacities and practices;**
- **Consequences of the change of practices;**
- **Conditions allowing the sustainability of the changes in capacities and practices** since they correspond to a shift in professional culture that can further influence the way breeding programs are les and managed in the future.

3.3.1 Increased acknowledgement of the importance of integrating end-user needs and preferences in breeding programs

Increased acknowledgement of the importance of integrating end-user needs and preferences in breeding programs

Raising awareness about the importance of integrating needs and preferences of end-users in breeding programs was the principal condition for developing the different activities and contributing to outcomes in capacities and practices. Hence, the development of all new practices already reflects such acknowledgement. This section summarizes qualitative data collected on this specific outcome from individual interviews or collective workshops.

Specific data on breeders:

> *"Before breeders mainly focused on agronomic and resistance traits and only considered few quality traits, the project shifted their focus towards a larger set"*
>
> *"The project is already a success story, cause the project made clear the urgency to understand what farmers want. Breeders used to rule the world of agriculture. Now it evolved to another quality and characteristic we want. This is a paradigm change."*

Organizations and practitioners that participated in RTBfoods were not at the same stage of awareness and integration of user needs and preferences. Cassava and sweetpotato programs in different organizations appeared as the ones having started this integration process before the others. **For these organizations RTBfoods contributed in giving more attention, in bringing "enthusiasm" and in structuring multidisciplinary interactions and in bringing techniques to better take these traits into account.**

The following are examples of how respondents describe RTBfoods contribution to changes in awareness and mindsets:

> *[the practice of] "Let them (farmers, processors) make food products out of the varieties in the trial and then assessing consumer preferences at the community level. Those things which are clearly*

RTBfoods activities are kind of starting to be owned by the breeding group. And not only in IITA but also in NRCRI."

"RTBfoods helped in institutionalising this whole research to understand farmer preferences, from roots up to foods and to understand the preferences along the whole value chain in different RTB crops."

"Consideration of quality traits was there (in the yam breeding programs) the project helped in raising the bar, adding new traits. … Now it's actually implemented and there is personal and institutional will to continue in this direction. Yam will definitely not return back".

" [user preferences on quality traits] have been taken from being a secondary issue to become a primary … knowing what breeding programs are producing in a detailed way by giving attention to the food quality is what RTBfoods has helped us achieving."

Documentary analysis, in particular the analysis of sweetpotato and yam project reports from 2017 to 2022, helps in confirming that quality traits were progressively growing in importance and taken into account.

In yam, looking at the frequency of some keywords, it is possible to observe that the term boiled only appeared two times in the 2018 annual report. In comparison, it appeared 36 times in 2022 and the term pounded that was not mentioned in 2018, appeared 12 times. It is to note that 2021 is the first reporting year of the 2nd phase of the project. The 2021 report reflects the new structure of the project where outputs on product profiles and phenotyping of quality traits were integrated.

In sweetpotato reports, references to quality traits (e.g. beta-carotene and Fe and Zn content, sweetness, poundability and fry quality) are already present in the oldest documents we considered (SASHA annual report 2017). Also, some of the main challenges and limitations were mentioned:

However, we still need to more clearly refine our understanding of sensory attributes of cooked and processed sweetpotato, and particularly in terms of consumer acceptance in Ghana.

Production of adequate quantities of storage roots of the parental genotypes to be used to develop of protocols for routine screening was a challenge, and we were unable to develop and implement tests for factors contributing to perishability …

The structure and achievements reported in 2021 show the progress made in addressing these challenges, in the prioritization of traits (gender and market segment analysis by country/district) and in the approaches and tools to assess some of them (e.g. colour, firmness, mealiness, sweetness).

In 2018 neither SASHA nor AfricaYam reports mentioned the collaboration with RTBfoods, references to joint activities become more frequent year after year (RTBfoods is cited 12 times in the SweetGains 2021 annual report). RTBfoods contribution in better integrating quality aspects in the second phases of the BMGF-funded breeding project has also been acknowledged in the interviews with key stakeholders.

Acknowledgment of the importance of specific preferences, roles and contributions of women

As most farmers and users involved in sensory testing or assessment of the quality traits **were women**, the data collected was gender responsive. New traits could be identified such as **the branchability of cassava and the impact of that trait on women's time spent in weeding.**

"This work involved such extensive consultation with women as producers as processors, as sellers, and that's the main thing, and that that information has been documented, and given to breeders and other food scientists to work with".

According to interviewees, an **unprecedented amount of data was collected on women preferences,** yet most of this data still has to be processed.

Women participation to trials and data collection process also contributed to increase their prestige and recognition amongst their farming communities as they were visited by people from other locations to observe their way of processing and as they had access to new planting materials. This outcome was observed in Nigeria, Uganda, Cameroon and for cassava and yam crops.

Awareness was also raised at a **political level in Uganda with the creation of partnerships about gender issues and end-user preferences** for breeding among local government, farmer groups and NGOs (Samaritan's Purse, World Vision) for sweet potatoes and potatoes.

Yet, as one respondent declare:

> *"Even through great advances have been made in gender transformative approaches, the overall context in SSA (and elsewhere?) is still heavily biased towards men, and is arguably entrenched... so more work needs to be done to facilitate such gender transformative approaches".*

3.3.2 Enhanced interdisciplinary dialogue

Main achievements

One of the main intermediary objectives of the RTBfoods project was to enhance dialogue between a diversity of disciplines in order to enrich breeding process with input and analysis from different field of investigation. The principal hypothesis of this project is that better interaction between disciplines will improve user preferred traits identification and integration in breeding process. The main disciplines participating in the projects were breeders, food scientists and social scientists.

According to our survey, RTBfoods was the **first experience of working with other disciplines for 1/3 of the respondents**. For this category as well as for respondents with previous multidisciplinary experiences, this project significantly improved their capacity to collaborate with other disciplines. RTBfoods project:

- Organized, structured and coordinated these interactions;
- Allowed for development of new partnership (i.e. collaboration between Cirad and NARL team) while reinforcing the existing ones;
- Raised awareness of specific contributions that different disciplines have in breeding programs when proactively working together to set up a research agenda.
- Concretely provided proof of concept that interdisciplinary dialogue could be feasible and bring added value to breeding process, a common mantra amongst RTBfoods being that

> *"Breeding is too important to be left to breeders alone".*

- Enhanced data sharing amongst disciplines:

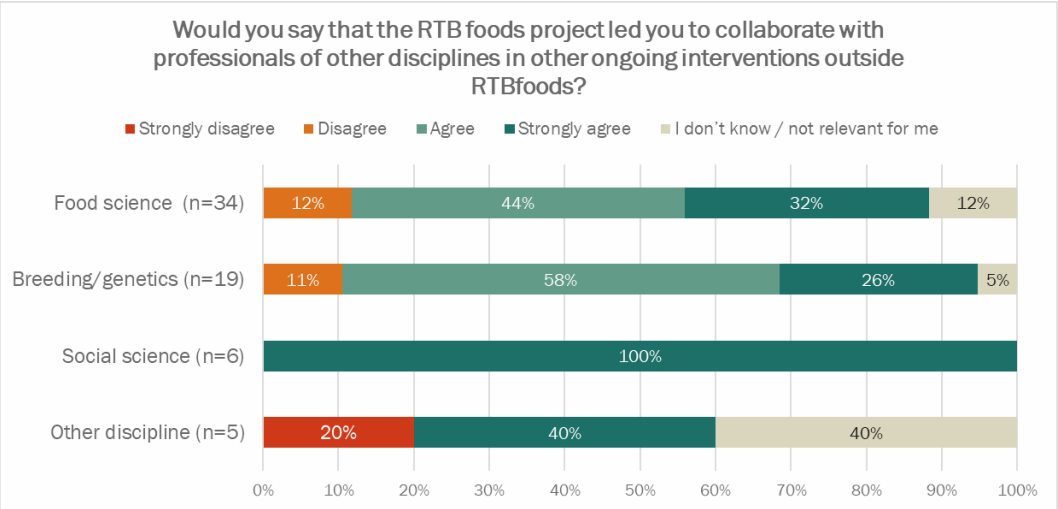
> *"The Yam breeders looked at what food scientists did, they checked what the lab did and the results that came out to the lab. They repeated the work and the results were the same as the ones received by FoodLab. So that confidence building open mindedness to say okay, this is what they're doing and it's useful"*

- Led to better understanding across disciplines (work on common vocabulary, understand different requirements and standards) mostly between food scientists and breeders but also with social scientists that became more familiar with the vocabulary, practices and tools of other disciplines. This improved the quality of their interaction with each other as well as their understanding of each other's needs;

> *"I can now understand why they want me [food scientist] to screen thousands of clones, which is not easy for me. And they [breeders] now understand that even though they need that, there is no easy way for me to go at that pace."*

Respondents to the survey estimated that this improvement of collaboration between disciplines led to **pursue such collaboration in other projects**. All social scientists agree to that statement and ¾ of food scientists and breeders agreed or strongly agreed to that statement.

Figure 10 : Answers analyzed by discipline to the question: "Would you say that the RTBfoods project led you to collaborate with professionals of other disciplines in other ongoing interventions outside RTBfoods?



Moreover, **the overall project also contributed to promote interdisciplinary dialogue and cooperation at an organizational level according to 80% of the survey respondents** and at an even proportion for all disciplines.

Ongoing work or challenges

Nevertheless, work in still ongoing in this area and progress are still needed in order to guarantee the quality and sustainability of this interdisciplinary dialogue.

- Further alignment of research objectives and sample selection among food scientists and breeders as well as additional efforts to make information produced by food scientists readily usable by breeders. For instance, the definition of range/classes or identification of satisfying thresholds on quality traits will allow for decision making in breeding process;
- Further collaboration among breeders and social scientists in the design of research activities to reinforce mutual understanding and allow for definition of shared objectives;
- Interaction between breeders and market intelligence is only nascent and was not directly addressed in the project;
- At last, it appears that albeit the previously mentioned evolutions, some respondents still observe that there is room for improvement to make the management of breeding process more inclusive.

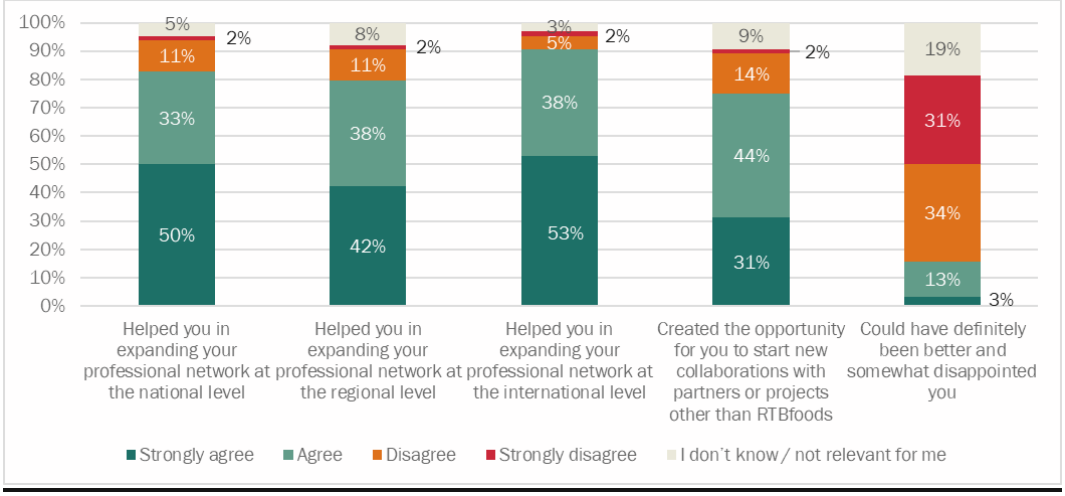
3.3.3 Enhanced network of institutes and projects on RTBs across countries

Another specificity of RTBfoods was to **organize common activities, data collections and analysis across RTB crops, CGIAR centers and national centers or other research institutions and countries**. This way to conduct activities also generated outcomes that potentially could be mobilized for conducting other projects.

According to our survey, all breeders, social scientists and 70 to 75% of food scientists agree or strongly agree that the RTBfoods project **helped them to expand their professional network at a national or regional level and** more than 90% of respondents recognized that it helped them to expand their network **at an international level.** Even more interestingly for the sustainability of this outcome, **¾ of the respondents, building on the opportunities created by the project, started**

new collaborations with partners or projects other than within RTBfoods. To many respondents this dimension of the project was one of its greater "side effect".

Figure 11 : Regarding collaborating with professionals working in other organizations or other projects, would you say that RTBfoods project: (n = 64)



The common activities organised in the project (trainings, workshops, meetings, webinars) were the main drivers for developing these collaborations.

Different kind of collaboration were developed:

- collaboration **across organizations and countries working on the same crops** (for instance reinforcement and development of collaboration on Cassava between IITA, CIAT and Universities in Benin or between Cirad and organisations in Côte d'Ivoire on bananas).
- Strengthening of collaboration **between organizations and countries across crops**: collaboration between CIAT, NaCRRI and Cirad.
- Collaboration **between organizations and other projects** and particularly NextGen and Africa Yam.

Respondents mostly described enhanced collaborations as:

- More structured and coordinated (both for existing and new collaborations);
- Fostering data sharing across institutes and countries;
- Promoting changes in the relationship: institutes are not just suppliers to each other but started real collaboration on a common project.

Image 5 : RTBfoods 2020 Annual Meeting in Kampala-Uganda, @P. Lajous, CIRAD.

4 KEY RECOMMENDATIONS

Bilateral interviews and participation in workshops and annual meetings were an opportunity to collect stakeholders' feedbacks on the design and the management of RTBfoods the project. Some of these feedbacks are briefly summarized here.

A largely positive appreciation of the project management and the performances of the project management unit (PMU) is shared among partners organisations. The PMU was able to *"bring partners together", "clarify the objectives of the project that were not well understood at the beginning", "motivating the team", "pushing the team", "being in contact with everybody", "facilitating the circulation of information"* through virtual and in-person meetings, frequent and regular webinars, coordinating the writing of good-quality annual reports and special issues. PMU is being acknowledged as able to be *"responsive, to provide guidance and support"*; a driving force for the project … sometimes "*too hard", too tough"* when expressing judgement on the work done and *"dogged"* in asking for more even when resources available were limited.

Adequation between project ambitions and available funding is the most cited challenge by partners when looking at the project design. The scope of work has been perceived as too broad (e.g. number of crops, food products, traits, partners, countries) given the available time and resources. A recommendation for a more focused and stepwise approach was formulated by several partners.

One of the few difficulties mentioned in the collaboration with sister projects is also related to this issue. In fact, sister projects had to allocate funding to activities related to quality assessment, which was not planned initially, some expected RTBfoods to be in capacity of taking on these costs entirely throughout the 5 years.

Important contributions in developing partners' capacities have been highlighted in the results of the survey. During bilateral and group discussions, partners insisted on the importance of the capacity development component of the project and national partners appreciated the availability of funding to upgrade their labs with new equipment.

Together with the assessment of the outcomes identified these feedbacks have been the basis for formulating the following recommendations.

- Consolidate and communicate achieved results on developing low, medium and high throughput phenotyping methods and tools for quality traits
    1. In the final period of the current phase, the project should focus on making accessible the results on methods and tools achieved so far or that can be validated and documented in the coming months. Manuals, training materials, tutorials and other products should be edited and diffused within the RTBfoods consortium and beyond. Opening new fronts should not be a priority.
    2. Also, the project should continue its efforts in cleaning, preparing and making accessible all the data that could be further used to calibrate and validate assessment methods and tools
- Prioritize and demonstrate
    1. In the final period of the current phase, particularly in the final project report, further document and highlight the cases where integration of information on quality traits has been achieved in decision-making processes in breeding programs.
    2. For the coming phase, identify (through multidisciplinary consultation) and concentrate efforts on a number of low, medium and high-throughput protocols in line with resources available and for which integration in decision-making processes along the breeding pipelines has a high probability to be successful / demonstrated.
    3. For the coming phase, identify a limited set of traits for which SOP and thresholds can be determined and validated rapidly.

- Integrate and institutionalize
    1. Build on the actual use of quality-related data to develop procedures and standards in relation with stage-gate approach and adapted to different organizational models. Proactively look for i) collaboration with breeding programs that have started a reflection on the organizational and management dimensions of the breeding programs; ii) collaboration with programs that follow different management models (e.g. breeding programs with strong and central leadership on multidisciplinary teams, breeding programs were breeding teams, food labs and social scientists are in different departments / under different leaderships).
    2. Generate data on effort / time needed to develop/adapt low, medium and high-throughput protocols for additional traits to better plan the investment needed

5 APPENDICES

5.1 Annex 1: List of people interviewed

5.1.1 Inception phase

Name	Organization	Discipline
Emmanuel ALAMU	IITA	Food science
Noel AKISSOE	UAC-FSA	Food science
Asrat AMELE	IITA	Breeding
Hernan CEBALLOS	Former CIAT	Breeding
Ugo CHIJIOKE	NRCRI	Food science
Lora FORSYTHE	NRI	Social and economic sciences
Ismail KAYONDO	IITA	Breeding
Tessy MADU	NRCRI	Food science
Christion MESTRES	CIRAD	Food science
Bolanle OTEGBAYO	Bowen University	Food science
Bela TEEKEN	IITA	Social and economic sciences

5.1.2 Substantiative phase

Name	Organization	Discipline
Patrick ADEBOLA	IITA	Breeding / Project management
Lukas MUELLER	BTI	Data science
Emmanuel CHAMBA	CSIR	Breeding
Xiaofei ZHANG	CIAT	Breeding
Canaan BOYER	Cornell	Project management
Hale TUFAN	Cornell	Social and economic sciences
Maria ANDRADE	CIP	Breeding
Vish BANDA	IITA	Social and economic sciences
Ephraim NUWAMANYA	NaCRRI	Food science

Name	Organization	Discipline
Michael KANAABI	NaCRRI	Breeding
Joseph ONYEKA	NRCRI	Plant Pathologist
Rony SWENNEN	IITA	Breeding
Busie MAZIYA-DIXON	IITA	Food science
Peter KULAKOW	IITA	Breeding
Hugo CAMPOS	CIP	Breeding
Amany Michel KOUAKOU	CNRA	Breeding
Eglantine FAUVELLE	CIRAD	Project manager

5.2 Annex 2: Main documents analysed

AfricaYam annual report 2018, 2019, 2020, 2021, 2022

Ceballos, H., Hershey, C., Iglesias, C. et al. Fifty years of a public cassava breeding program: evolution of breeding objectives, methods, and decision-making processes. Theor Appl Genet 134, 2335–2353 (2021).

Christiane Koffi Adjo, Boni N'Zué, Catherine Ebah Bomoh, Sidoine Essis Brice, Sylvie Diby N'Nan Affoué, Konan Dibi, Amani Michel Kouakou & Assanvo Simon Pierre N'guetta (2021). Agronomic Evaluation of Some Cassava Varieties (Manihot Esculenta Crantz) and Sensory Evaluation of Attieke from These Varieties in Three Agro-Ecological Zones of Cote D'ivoire. International Journal of Agriculture and Biological Sciences. Nov & Dec 2021 December 31, 51-67.

Dansi A., Product advancement and refinement meeting (Benin component) AfricaYam project. University of Abomey-Calavi. 2021

Iheukwumere Amadi, News posted on December 21, 2020. MSMEs Today.Com

Ikeogu UN, Davrieux F, Dufour D, Ceballos H, Egesi CN, et al. (2017) Rapid analyses of dry matter content and carotenoids in fresh cassava roots using a portable visible and near infrared spectrometer (Vis/NIRS). PLOS ONE 12(12): e0188918. https://doi.org/10.1371/journal.pone.0188918

Iragaba P., Nuwamanya Ephraim, Wembabazi Enoch, Baguma Yona, Dufour Dominique, Earle E.D., Kerr R.B., Tufan Hale, Gore Michael A., Kawuki R.S.. 2019. Estimates for heritability and consumer-validation of a penetrometer method for phenotyping softness of cooked cassava roots. African Crop Science Journal, 27 (2) : 147-163. https://doi.org/10.4314/acsj.v27i2.3

NextGen Cassava annual report 2018, 2019, 2020, 2021, 2022

Polar, V. et al. (2022). Building Demand-Led and Gender-Responsive Breeding Programs. In: Thiele, G., Friedmann, M., Campos, H., Polar, V., Bentley, J.W. (eds) Root, Tuber and Banana Food System Innovations. Springer, Cham.

RTBfoods annual report 2018, 2019, 2020, 2021

SASHA annual report 2018, 2019

SweetGAINS annual report 2020, 2021

Teeken B, Garner E, Agbona A, Balogun I, Olaosebikan O, Bello A, Madu T, Okoye B, Egesi C, Kulakow P and Tufan HA (2021) Beyond "Women's Traits": Exploring How Gender, Social

Difference, and Household Characteristics Influence Trait Preferences. Front. Sustain. Food Syst. 5:740926. doi: 10.3389/fsufs.2021.740926

Teeken Béla, Agbona Afolabi, Abolore Bello, Olaosebikan Olamide, Alamu Emmanuel, Adesokan Michael, Awoyale Wasiu, Madu Tessy, Okoye Benjamin, Chijioke Ugo, Owoade Durodola, Okoro Maria, Bouniol Alexandre, Dufour Dominique, Hershey Clair, Rabbi Ismail Y., Maziya-Dixon Busie, Egesi Chiedozie, Tufan Hale, Kulakow Peter. 2021. Understanding cassava varietal preferences through pairwise ranking of gari-eba and fufu prepared by local farmer-processors. International Journal of Food Science and Technology, 56 (3), n.spéc. Consumers have their say: Assessing preferred quality traits of roots, tubers and cooking bananas, and implications for breeding: 1258-1277.

Thiele, G., Dufour, D., Vernier, P., Mwanga, R.O.M., Parker, M.L., Schulte Geldermann, E., Teeken, B., Wossen, T., Gotor, E., Kikulwe, E., Tufan, H., Sinelle, S., Kouakou, A.M., Friedmann, M., Polar, V. and Hershey, C. (2021), A review of varietal change in roots, tubers and bananas: consumer preferences and other drivers of adoption and implications for breeding. Int. J. Food Sci. Technol., 56: 1076-1092. https://doi.org/10.1111/ijfs.14684

Uchendu K, Njoku DN, Paterne A, Rabbi IY, Dzidzienyo D, Tongoona P, Offei S, Egesi C. Genome-Wide Association Study of Root Mealiness and Other Texture-Associated Traits in Cassava. Front Plant Sci. 2021 Dec 17;12:770434. doi: 10.3389/fpls.2021.770434. PMID: 34975953; PMCID: PMC8719520.

5.3 Annex 3: Documented cases where quality traits were used in breeding programs (in relation with RTBfoods)

Crop	Source	Organization	Quotation or Synthesis of key information
Cassava	RTBfoods annual report 2021	NextGen Cassava	In the cassava NextGen breeding programs in Uganda and Nigeria, 9 C1 clones and 5 top-performing clones, respectively, have been advanced for evaluation using the TRICOT approach developed under NextGen. Joint contribution of RTBfoods
Cassava	RTBfoods annual report 2021	CIAT	At CIAT-Colombia 8 best advanced cassava clones have been selected for laboratory, sensory and consumer evaluation within WP5.
Cassava	RTBfoods annual report 2021	NaCRRI	Among the 11 cassava clones evaluated during consumer testing, elite clone UG120193 was identified as the best clone for processing boiled cassava.
Cassava	RTBfoods annual report 2021	NRCRI	Concerning gari-eba, 17 clones were planted by NRCRI in 3 locations namely: Umudike, Otobi and Igbariam in Nigeria.
Cassava	RTBfoods annual report 2021	IITA	Meanwhile IITA evaluated 6 advanced clones for the same purpose in 2 locations (Osun state and Benue state).
Cassava	RTBfoods annual report 2021	NextGen Cassava	Consumer hedonic testing among 300 consumers in each of Benue and Osun states using the TRICOT methodology was successfully implemented. 10 varieties grown in the two locations, and processing into Gari for Eba by champion processors. The evaluation was therefore all inclusive at both processor and consumer levels.

Crop	Source	Organization	Quotation or Synthesis of key information
Cassava	RTBfoods annual report 2021	CNRA	Concerning attiéké, the evaluations made by the CNRA team on 7 advanced cassava clones showed that the quantity of residual fibers in the end product is the discriminating characteristic for acceptability. Moreover, the results showed that 2 new clones (Agba Blé 3 and Yavo) were preferred to the local reference variety.
Cassava	NextGen Cassava annual report 2022	NextGen Cassava, NaCRRI	NaCRRI: Three clones (UG120193, UG120156 and Mkumba) have been submitted for variety release. We await the invitation to meet again with the committee, following the meeting that was held on 15th February 2022 with National Seed Certification Unit (NSCU) to fast-track the variety release process. As indicated earlier, C1 clones are also in the pipeline for release. Accordingly, C1 clones (comprising 7 to 10 clones) are concurrently undergoing both National Performance Trials (NPTs) and TRICOT evaluation. NPTs are being conducted at six sites, while TRICOT trials are being conducted by 480 farmers located in 10 districts: Luwero (targeting boiled root market segment), Buikwe (targeting boiled root market segment), Kibaale (targeting boiled root market segment), Tororo (targeting flour market segment), Serere (targeting both flour and boiled root market segment), Busia (targeting flour market segment), Dokolo (targeting both flour and boiled root market segment), Arua (targeting flour market segment), Zombo (targeting flour market segment) and Bundibugyo (targeting flour market segment). “Distinctiveness” “Uniformity” and “Stability” assessment trials have also been established across five sites for monitoring by NSCU. Datasets and information associated with all these trials is available on CassavaBase (see Figure 108, Appendix 1H). RTBfoods contribution is not clearly stated. Co-funding of TRICOT-related activities to be confirmed.
Cassava	NextGen Cassava annual report 2021	NextGen Cassava, NRCRI, IITA	The standout achievement of the project in Period 3 was the official release in Nigeria of five NextGen cassava clones. These varieties were named and launched in the formal cassava seed system. These varieties, named Game-Changer, Baba70, Hope, Obasanjo-2, and Poundable, deliver promising options for smallholder farmers in resisting cassava diseases, obtaining high yields, and marketing their crops to consumers. ‘Poundable’ is the first fresh market variety released in Nigeria. ‘Hope’ and ‘Baba-70’ have excellent gari and fufu quality to address the processed food market. ‘Game-Changer’ and ‘Obasanjo-2’ have high and stable starch content, which is desired by industrial processors for flour, starch and ethanol. Released varieties clearly target specific market segments and user needs. RTBfoods contribution is not clearly stated.
Cassava	NextGen Cassava annual report 2021	NextGen Cassava	Nigeria: Based on the product advancement meeting held in Period 3, advanced materials were selected and planted on-station in two states in Nigeria to evaluate in a surrounding community, with local experienced ‘champion processors’. The objective is to evaluate these varieties for processability and food quality in relation to local best varieties, as determined by the champion processors as well as in relation to the dominant variety in the regions as informed by the CMS study.

Crop	Source	Organization	Quotation or Synthesis of key information
			Fresh roots and intermediate gari products will be taken to the laboratory for analysis to inform how a good root and intermediate food product is defined in order to 'calibrate' laboratory values on processing and food quality evaluation, as well as the SoPs for gari and eba preparations as developed by the food science lab. This is done in cooperation with RTBfoods. Following the sampling frame of the survey on user preferences in Nigeria and Cameroon for the product profile of gari-eba for which analysis has been completed and published (Ndjouenkeu et al 2021), two trials have been set up for evaluation in Period 4: one in Otobi (Benue State) and one in Agoowu (Osun State). These comprise the varieties that were identified during the 2020 product advancement meeting, and includes two newly released varieties. A trial in the littoral zone in Cameroon will be installed in Period 4 and will comprise the same elite and released clones. An additional activity that was developed was that the same clones plus three biofortified cassava clones will be shipped to Benin for an equal in-village evaluation of the varieties within the gari product profile in cooperation with CIRAD. Preparation for shipment has been arranged. Samples of roots and foods will be taken to the lab to support calibration of laboratory processing and preparation of food products (IITA food lab for Benue and Osun trials in Nigeria, CARBAP and the University of Ngaoundéré for Cameroon and CIRAD for Benin.) RTBfoods contribution / collaboration clearly stated (for the enitre section of the report)
Cassava	NextGen Cassava annual report 2020	NextGen Cassava, IITA	At IITA: More than 70% end-users of cassava in Nigeria consider the quality of garri and fufu very important (Wossen et al., 2018). Thus, in addition to phenotyping for agronomic and yield traits, clones from late stage selections (UYT and NCRP) were subjected to evaluation of garri and fufu (see table below). A total of 928 products were produced from four trials – GS.C2.UYT36.SetA, GS.C2.UYT36.SetB, 18.GS.C1.C2.UYT.26, and NCRPs – each with two replications and locations. For each product, we processed 20 kg of fresh roots. The protocol of garri and fufu processing was described in last period's report All data generated from these trials are added to our population improvement pipelines through the selection of parents that have very high genetic variances for these traits. Our variety replacement strategies have evolved to include post-harvest traits and hence better varieties are expected in the near future.
Cassava	NextGen Cassava annual report 2020	NextGen Cassava, NRCRI	At NRCRI: two NRCRI team members (Lydia and Damian) participated in the EiB facilitated training workshop on the importance of Product Profiles design by breeding programs. This workshop followed EiB's guided effort towards developing a Product Profile for NRCRI NextGen project. The profile designed aimed at cassava varieties suitable for the food sector (gari and fufu). The new product will target the replacement of three popular varieties (TMEB419, NR8082, TMS30572). Basic traits for the product include High dry matter content, CMD tolerance, good gari quality and good fufu quality. The value-added

Crop	Source	Organization	Quotation or Synthesis of key information
			traits and the target environment are summarized in the table below.
Cassava	NextGen Cassava annual report 2020	NextGen Cassava, NaCRRI	At NaCRRI: During the past year, we have had advice-giving engagements with Excellence in Breeding (EiB) and RTB-Foods Project, with a purpose defining and understanding cassava's priority "Product Profile" so as to develop and undertake responsive cassava breeding operations. Accordingly, three significant milestones have been identified. Firstly, through surveys conducted that targeted key value-chain actors involved in cassava production, retail marketing and consumption, we identified "softness of boiled roots" as a highly preferred cassava food product. Consequently, we undertook process diagnosis and defined traits that characterize quality of boiled cassava. For this we identified a total of 21 attributes: four attributes associated with appearance; seven attributes associated with texture in the mouth; three attributes associated with texture by touch; three attributes associated with taste; four attributes associated with aroma. Secondly, we initiated the process of integrating "softness of boiled roots" in our breeding operations; this was done for both early and late evaluation stages. For early breeding stages (stage-gate 2 and stage-gate 3), focus is on development of calibration models that enable swift adoption of near infra-red spectrometry (NIRS) for measurement of softness of boiled cassava roots. For the late breeding stages i.e.., for the TRICOT evaluations, we have used some of the identified quality attributes (described above) in assessing the suitability of our elite C0 cassava clones. Finally, we have contributed towards the step-by-step process of harmonization of the "Product Profile" development.
Cassava	NextGen Cassava annual report 2020	NextGen Cassava, TARI	TARI recently conducted a survey to understand farmer-market-consumer preferences in two major cassava growing areas in Tanzania. These included the Lake Victoria area (known as the Lake Zone) and the Coastal Lowland (known as the Eastern Zone). In the survey we focused on key value chain actors from cassava production, rural wholesale and retail marketing, processing and consumption characteristics. We identified that boiled cassava for fresh consumption was key market demand in the Eastern Zone. And traits associated with fresh consumption included several key trait categories including: cassava productivity; cooking qualities; eating qualities; general appearance; taste and aroma, and texture of the boiled cassava. In the Lake Zone, on the contrary, the key product is flour for making stiff porridge known as ugali and key traits associated with good cassava flour include: cassava productivity, peeling qualities, processing and cooking qualities, taste and aroma, texture in the mount and by touch. TARI therefore has two major product profiles: fresh consumption and processed ugali. In addition, we are developing an industrial product profiles for industrial use targeting developing cassava varieties with traits for industrial use. In our cassava variety replacement strategy, our selection is mainly focusing on the market-demanded added traits

Crop	Source	Organization	Quotation or Synthesis of key information
			that contribute to fresh consumption and flour processing for Eastern Zone and Lake Zone respectively as well as for High Quality Cassava Flour and Starch. We are hoping to utilise findings on use of NIRS from our partner breeding programs to incorporate food products traits (softness, etc.) for variety selection in C1. We also have initiated the main TRICOT in the Eastern Zone and participating farmers are evaluating a total of 20 varieties that we hope to get feedback on farmers' trait preferences for fresh consumption. As part of continuous improvement, TARI is currently forming cross functional teams for designing, selection and advancement of the products. We will continue to conduct market survey and market analysis to inform the breeding program on the traits preferred by consumers for fresh and processing products. Spill-over effects
Cassava	NextGen Cassava annual report 2020	NextGen Cassava, IITA, NRCRI	In Nigeria, nomination of varieties for release, led by NRCRI completed the first season of NCRP trials in 2019. The second year NCRP trials were planted in ten locations and on farm trials were planted for representing 5 Nextgen clones and 2 checks. Data from these trials have been analyzed and presented at the Product Advancement Meeting that was held on 6 May 2020, from which 3 clones are the most promising candidates: TMS13F1160P004, TMS13F1343P0022, and NR130124. The identification of these clones is based on multi-disciplinary evaluation through data from breeders' fields, food quality analysis, farmers participatory evaluation, the NCRP trial and on-farm trials. Direct contribution of RTBfoods is not stated
Cassava	NextGen Cassava annual report 2020	NextGen Cassava, IITA, NRCRI, TARI, NaCRRI	We are proposing that this milestone's output be modified, changing the wording from "ideotype" to "product advancement". Guided by EiB, yearly product advancement meetings are held regionally enabling integration of survey division research work, as well as results from RTBFOODS work package 1. The first West Africa product advancement meeting was held virtually in April 2020, with attendance from NRCRI, IITA, TARI and NaCRRI. The East Africa product advancement meeting will be held in Year 3, bringing together TARI and NaCRRI to present research results feeding into product profile development, and plans for the next year.
Cooking banana	RTBfoods annual report 2021	ABBB, NARL, IITA	Consumer testing is also carried out in villages where elite clones are assessed for quality in a participatory manner (WP5).
Cooking banana	RTBfoods annual report 2021	NARL/NARO	5 genotypes were selected and already established in one on-farm trial in 4 sites, fully handled and managed by the banana breeding program at NARL/NARO.
Cooking banana	RTBfoods annual report 2021	CARBAP, IITA	Regarding boiled plantain, ten genotypes including 8 clones from two breeding programs namely: CARBAP and IITA, and 2 local checks produced in two localities in Cameroon: Njombe, and Bansoa were evaluated for agronomic and postharvest qualities. Forty participants mostly plantain

Crop	Source	Organization	Quotation or Synthesis of key information
			nursery operators, plantain farmers, plantain vendors, processors and consumers were invited for the two participatory evaluation sessions of the mentioned genotypes. Furthermore, fruits from CARBAP K74, CARBAP 838, PITA 14 and PITA 21 were used for a preliminary sensory evaluation (consumer testing). The plantain hybrids from CARBAP and IITA will undergo a complementary evaluation according to WP5 developed methodology guidance during Period 5.
Cooking banana	RTBfoods annual report 2021	CNRA	Regarding fried plantain, CNRA planted and harvested 10 genotypes. Bunches have been analyzed for postharvest qualities. An evaluation with processors and consumers will be carried out in the second quarter of Period 5.
Sweetpotato	RTBfoods annual report 2021	SweetGains, CIP, NaCRRI	Participatory varietal selection (PVS) tests are being implemented in coordination with WP5. Uganda and Mozambique
Sweetpotato	RTBfoods annual report 2021		5 performing clones will be advanced based on their promising results in terms of firmness and mealiness.
Sweetpotato	RTBfoods annual report 2021	CIP, NaCRRI	For boiled sweetpotato, CIP and NaCRRI in Uganda established participatory on-farm trials to evaluate five advanced clones namely: D11, D20, S47, NKB3 and NKB105 from both the two-institute breeding programmes. The trials were planted in September 2021 in 15 districts in Uganda representing five agro-ecological zones. The trials also include 2 market-preferred varieties namely Muwulu Aduduma, and Umbrella. The harvested roots will be used for processing and consumer testing using the tricot method in Period 5.
Sweetpotato	RTBfoods annual report 2021	CIP	Concerning fried sweetpotato, 15 genotypes comprising both released and advanced clones were evaluated for consumer acceptability using the best-worst scale and 9-point hedonic scale in Ghana. Genotypes SARI-Nan, CRI-Ligri, SARI-Nyumingre, PGA14008-15 and CRI-Yiedie were identified as the most preferred fried sweetpotato varieties. Sweetpotato taste was identified as the driving force for the preference of fried sweetpotato varieties. Specifically, fries with moderately sweet (33%) to highly sweet taste (36%) influenced decision of best genotype choice, though some consumers preferred less-sweet fries.
Sweetpotato	RTBfoods annual report 2021		For fried sweetpotato, a participatory selection of 12 clones was conducted in two regions in Côte d'Ivoire (Korhogo and Bouaké). Two taste tests were conducted per village to determine which varieties were the most popular and had a good yield regarding fried and boiled sweetpotato. Finally, four orange-fleshed varieties (Covington, Kakamega-7-Irene, TIB-440060 and CIP-199062-1) recorded the highest sugar and beta-carotene contents while three white-fleshed varieties (Chinois wosso, Wesse pou and Sanfo figui1) recorded the highest dry matter contents.

Crop	Source	Organization	Quotation or Synthesis of key information
Yam	RTBfoods annual report 2021	IITA	At IITA-Nigeria, 2 yam clones have been clustered as promising and will be shared with WP5 for evaluation with processors and consumers.
Yam	RTBfoods annual report 2021	CIRAD	At CIRAD-Guadeloupe 25 clones have been identified as having good tuber shape, yield, colour and taste. They will be advanced for participatory evaluation.
Yam	RTBfoods annual report 2021	CNRA	At CNRA-Côte d'Ivoire, 5 elite clones (2 D. rotundata and 3 D. alata) were selected for their high yields and for the good quality of the final pounded and boiled yam products. They are currently planted in two contrasting environments and some of them are to be advanced in WP5 for participatory evaluation.
Yam	RTBfoods annual report 2021	IITA	The IITA yam-breeding program assessed 16 white and 10 water yam advanced clones for boiled and pounded yam product quality in Period 4. Based on superiority for agronomic performance and quality for boiled and pounded yam products, test clones TDr140120 and TDr1400158 were found to be superior to the popular farmer variety Meccakusa and released cultivar TDr TDr8902665.
Yam	Dansi A., Product advancement and refinement meeting (Benin component) AfricaYam project. University of Abomey-Calavi. 2021	University of Abomey-Calavi (UAC), AfricaYam, CRP RTB	Evidence of participatory evaluation of 15 traits, including traits influencing food product quality, for 44 varieties (to be confirmed, not clearly specified). Evidence of assessment of culinary acceptability of 15 yam D.rotundata clones received from IITA and utilization of food quality as criterion for decision making on clone advancement. Evidence of assessment of culinary acceptability of 12 local varieties and 4 hybrids of yam (D. rotundata) in four agro ecological zones in Benin and utilization of food quality as criterion for decision making on registration / release. Based on the presentation a direct linkage with RTBfoods quality assessment tools and procedures is not possible.

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