CIAT achievements in Period 1

Activities Conducted, & Perspectives

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PARTNER Summary

During Period 1, CIAT has implemented the following activities: Firstly, a database of biophysical traits (composition, cooking time & texture of raw and cooked roots) and NIRS spectra was established for 150 genotypes of cassava harvested in 2018, in preparation for investigating correlations and predictive algorithms between NIRS and biophysical data. This database will be expanded to 450-500 entries by adding data from upcoming harvests in 2019 and 2020. We expect this number will allow identifying robust correlations, and hence reliable HTPP predictions by NIRS of some of the quality traits of boiled cassava. As part of this work, to better describe the texture of cassava roots, a new texture protocol was developed, by screening several types of probes and measurement conditions to identify the configuration that optimizes coefficients of variation. This protocol was used to generate the texture data in the database of biophysical traits of boiled cassava.

Secondly, exploratory research was conducted to extract cell wall materials (CWM) from cassava roots and investigate correlations between CWM and quality traits of boiled cassava (texture, etc.). An extraction protocol of CWM was established, and CWM from 30 genotypes with contrasting cooking times (15 to more than 60 mins) were extracted. The extracts were characterized by NIRS and MIRS, and potential correlations with texture are being investigated.

Thirdly, seven standard operating protocols (SOPs) in use at CIAT for biophysical characterizations of cassava roots were inventoried and made available on the RTBfoods online platform.

Fourthly, genotypes with short to long cooking times, together with low cyanide, were selected and planted for crossings, in order to determine the heritability of the trait short cooking ability. Flowering and crossing are expected in the first quarter of 2019

PARTNER activities

PARTNER participation in the different WPs & cross-WP interactions

In Period 1 CIAT was involved in WP2, WP3 and WP4.

WP2:

1. Inventory of the biophysical methods used at CIAT for characterization of RTB crops, in particular cassava. The standard operating protocols (SOPs) of these methods were uploaded to the RTBfoods online platform.

2. Development of the following two methods:

- A method to measure the texture of raw cassava roots and boiled cassava roots. After screening several texture probes, a penetration test with a cylinder probe (3 mm diameter) was identified as the most practical. Key advantages were to avoid breaking the roots during the test (in particular boiled roots), and minimizing the coefficients of variation. A SOP was developed and uploaded to the RTBfoods online platform, together with a report (powerpoint format) on the various tests conducted during texture method development.

- A method to extract cell walls materials (CWM) from cassava flours. The method is adapted from references in the scientific literature, and is based on enzymatic hydrolysis of starch followed by precipitation of the CWM with increasing concentrations of acetone. The method development is reported in a MSc report uploaded to the RTBfoods online platform.

3. Application of the new texture method to characterize raw cassava roots from 270 genotypes and changes in texture during boiling of 150 genotypes of. Initial results indicate the following:

Firstly, hardness dropped quickly within the first 10 minutes, with an average decrease of 77% from the initial hardness (measured at total area under the texture curve). All genotypes, in spite of the diversity of origin and specific hardness, behaved in a remarkably similar way on this aspect, with a coefficient of variation of 7.6% for the loss of hardness, compared to a coefficient of variation of 27.4% for the hardness after 10 minutes boiling. This points to an underlying molecular mechanism nearly identical for all genotypes, most probably starch gelatinization.

Secondly, in spite of this major change in hardness, further boiling until "optimum cooking time" was necessary to achieve the mealy texture preferred by consumers. Whereas the initial drop in hardness was similar among all genotypes, optimum cooking time was highly diversified, ranging from 15 up to 60 minutes with a coefficient of variation of 40%. Some genotypes never actually reached the target mealy texture. These observations confirmed the distinct roles of starch (general drop in hardness) and of other components such as pectins and cell wall materials (CWM) in developing the final texture of boiled cassava. Given the higher variability in cooking time, the key determining factor of cooking ability and quality seems to be the CWM fraction (and its composition and changes during boiling), rather than the starch fraction

Finally, the texture of the raw roots was a poor predictor of the texture of roots after boiling, i.e. the hardest raw roots are not necessarily the hardest roots after boiling.

4. Application of the CWM extraction method to flours from 30 cassava genotypes, for which cooking time and texture data are available. The 30 flours were selected from the 2018 harvest to represent a wide range of cooking times, from short cooking (15-25 minutes) to long cooking (60 minutes or more).

WP3:

WP3 activities were developed in collaboration between CIAT and CIRAD (Fabrice Davrieux, Karima Meghar).

- NIRS analysis of the 30 CWM extracts from cassava genotypes representing a wide range of cooking times, from short cooking to long cooking. The NIRS spectra of the corresponding flours (before CWM extraction) and fresh roots were also recorded and are available.
- MIRS analysis of the 30 CWM extracts. The MIRS spectra of the corresponding flours (before CWM extraction) were also recorded and are available.
- Search for correlations between texture data and NIRS & MIRS data. Further investigations are pending (data analyses, detailed analysis of the composition of the CWM, improvement of the texture protocol). In period 1 it was possible to carry out 30 CWM extractions; however further extractions will be needed in order to increase the size of the database, considering that the minimum to investigate correlations between biophysical data and NIRS data is 150-200 samples.
- Transfer of the equations for prediction by NIRS of dry matter and carotenoids developed with CIAT cassava materials (2013 version), to RTBfoods partner NaCCRI.

WP4:

Genotypes with short to long cooking times, together with low cyanide, were selected and planted for crossings, in order to determine the heritability of the trait short cooking ability. Flowering and crossing are expected in the first quarter of 2019. The materials selected for the crosses are listed below. Crossing nurseries will benefit from the recently developed protocols to induce earlier and more profuse flowering in cassava through the extension of photoperiod by illuminating plants with red light during the night, application of plant growth regulators, and/or pruning of young branches to promote ealier and more abundant fruit and seed set.

Good cooking quality (white parenchyma): CM 2600-2; CM 2766-5; CM 5253-1; CM 7436-7; SM 1127-8; MCOL 1505M; MCOL 2066; MCOL 2246; MCR 138; MGUA 24; MMAL 3; MMEX 2; MPAN 70; MPAN 139; MPAR 57; MPAR 98; MPER 183; MPER 496; MVEN 77; MVEN 208; MVEN 218; MCUB 74.

Good cooking quality (yellow parenchyma): GM 3674-41; GM 8373-46; GM 8391-4; GM 8413-1; SM 3759-36

Poor cooking quality and high cyanogenic potential: MBRA 318; MBRA 325; MBRA 512; MCOL 1722; MCOL 1910; MCUB 46; MVEN 25

In addition, nurseries to increase planning material for clones adapted to the sub-humid environment of Colombia contrasting for their root quality traits were planted by mid-2018. The stem cuttings from these genotypes will be used to assess the effect of genotype x environment interaction on cooking quality (including age of the plants and harvesting season).

PARTNER geographic implementation / strategy

Activities are implemented in Colombia, making use of the genetic diversity of the cassava germplasm collection available at CIAT to characterize the variability of user traits, in particular for boiled cassava. The outputs (protocols, infrared calibrations, etc.) can be applied in other countries of the RTBfoods project.

PARTNER Product Profile participation

In Period 1, CIAT has worked on the boiled cassava product profile.

PARTNER Personnel involved & Students activities

During period 1, the following persons were involved in the RTBfoods project, all in Colombia on the boiled cassava product profile:

Name	***WPs***	***Activity***
Jhon Larry Moreno	WP2	Preparation and analyses of samples from raw cassava roots and boiled cassava Supervision of MSc student Nourdène Dhaouadi
Monica Pizarro	WP2	Preparation and analyses of samples from raw cassava roots and boiled cassava
Maria Alejandra Ospina	WP2	Development of the new texture SOP for raw and boiled cassava Preparation and analyses of samples from raw cassava roots and boiled cassava
Andrés Escobar	WP2	Development of the new texture SOP for raw and boiled cassava
Jorge Luna	WP2	Preparation and analyses of samples from raw cassava roots and boiled cassava
William Trivino	WP2	Preparation and analyses of samples from raw cassava roots and boiled cassava Development of the new texture SOP for raw and boiled cassava
John Belalcazar	WP2	As head of the post-harvest laboratory, planning and coordination of the activities for the RTBfoods. Analyses of the NIRS data from the CWM extracts, as well as from fresh roots.
Thierry Tran	WP2	Scientific leadership Inception meeting in Cameroun
Nelson Morante	WP4	Coordinator of crossing nurseries to produce botanical seed from selected genotypes. Will produce botanical seed for segregation studies
Jorge I. Lenis	WP4	Coordinator of research activities in the sub-humid environment in Colombia. Will coordinate planting and harvesting trials to assess GxE studies on cooking quality
Hernan Ceballos	WP4	Scientific leadership in the area of cassava breeding

List of Students involved in RTBfoods activities in Period 1:

NAME Surname	***Master Student or PhD or Post-Doc***	***Subject Title***	***University of affiliation***	***Fellowship Starting Date***	***Fellowship Ending date***	***Tutor(s) in RTBfoods project***
DHAOUADI Nourdène	MSc	Extraction and analysis by NIRS of cell walls from cassava roots	Supagro Montpellier (France)	01 April 2018	30 September 2018	Jhon Larry MORENO Thierry TRAN

PARTNER Travels: Participation to RTBfoods meetings & International Events on RTBfoods budget

Number of People or List of NAMES	***RTBfoods meetings***	***International / Regional Conferences***	***Dates***
Thierry Tran	Kick-off meeting, Buea, Cameroon		22-28 January 2018
Luis Augusto Becerra	Kick-off meeting, Buea, Cameroon		22-28 January 2018

PARTNER Capital Equipment or investment (co-investments)

Two equipment were acquired in 2018:

- NIRS Foss DS2500
- RVA 4500 (Newport / Perten) (delivery expected in early 2019)

Co-funding from other projects (Harvest+, RTB) have enabled purchasing both equipment in Period 1.

PARTNER Training participations (within RTBfoods framework and other trainings)

No training participation was planned in Period 1. Fabrice Davrieux (WP3 leader) and Karima Meghar (NIRS specialist at CIRAD – UMR Qualisud) came to CIAT from 26 October to 2 November 2018 (one week). In collaboration with the CIAT team, they revised the data generated in 2018 and investigated correlations between biophysical characterizations and NIRS of cassava genotypes, in particular dry matter, starch content, cyanide and texture of raw roots and boiled roots. Traits such as dry matter and starch content yielded promising results for NIRS predictions, while more data need to be accumulated for texture traits.

Training Title / Topic		*WP concerned (if training within RTBfoods framework)*	*Country*	*Dates*	*List of Participants NAMES*

PARTNER Sub-awards & Consultants

There were no sub-awards and consultants activities in Period 1.

PARTNER Other Sources of Support for RTBfoods activities

The RTBfoods activities at CIAT are organized in synergy with other projects of the Cassava Program, in particular the CGIAR RTB (Roots, Tubers and Bananas). Key contributions from RTB funding include (i) production of the cassava roots from 270 genotypes representative of the genetic diversity of cassava in Latin America; (ii) personnel time not covered by RTBfoods; (iii) co-funding for capital equipment (RVA 4500).

In Period 1, the Harvest+ program also contributed co-funding for capital equipment (NIRS DS2500).

PARTNER List of Publications, Conference communications, Manuals, Leaflets, Posters, etc.

Conference communications:

Dufour D., Fliedel G., Bouniol A., Davrieux F., Tran T., 2018. Cassava traits and end-user preference. *IVth International Cassava Conference - GCP21*, Cotonou, Bénin, 11-15 June 2018.

Ospina M.A., Tran T., Pizarro M., Luna Melendez J.L., Trivino-Palacios W., Belalcazar Martinez J.E., Salazar S.M., Dufour D., Becera Lopez Lavalle L.A., 2018. Diversity of post-harvest phenotypic traits among the CIAT cassava germplasm collection. *IVth International Cassava Conference - GCP21*, Cotonou, Bénin, 11-15 June 2018.

Ospina M.A., Tran T., Pizarro M., Luna Melendez J.L., Trivino-Palacios W., Belalcazar J., Martinez J.E., Salazar S., Dufour D., Becerra Lopez Lavalle L.A., 2018. Phenotyping postharvest physiological deterioration (PPD) in cassava: Implications for selection. *18th Triennial Symposium of the International Society for Tropical Root Crops (ISTRC)*, Cali, Colombia, 22-25 October 2018.

Luna Melendez J.L., Tran T., Pizarro M., Ospina M.A., Trivino-Palacios W., Belalcazar J., Martinez J.E., Salazar S.M., Dufour D., Becerra Lopez Lavalle L.A., 2018. Diversity of post-harvest phenotypic traits among the CIAT cassava germplasm collection. *18th Triennial Symposium of the International Society for Tropical Root Crops (ISTRC)*, Cali, Colombie, 22-25 October 2018.

Pizarro M., Ospina M.A., Luna Melendez J.L., Belalcazar Martinez J.E., Salazar S., Tran T., Becerra Lopez Lavalle L.A., Dufour D., 2018. Cyanide content and distribution in cassava plants, in association with physiological age. 18th Triennial Symposium of the International Society for Tropical Root Crops (ISTRC), Cali, Colombia, 22-25 October 2018.

Publications in peer-reviewed journals:

Escobar A., Dahdouh L., Rondet E., Ricci J., Dufour D., Tran T., Cuq B., Delalonde M., 2018. Development of a Novel Integrated Approach to Monitor Processing of Cassava Roots into Gari: Macroscopic and Microscopic Scales. *Food and Bioprocess Technology*, **11**, 1370-1380. **doi.org/10.1007/s11947-018-2106-5.**

Giraldo Toro A., Briffaz A., Gibert O., Dufour D., Tran T., Bohuon P., 2018. Modelling of heat and water transport in plantain during steeping to predict gelatinization and in vitro starch digestibility. *Journal of Food Engineering*, **235**, 1-8. **doi.org/10.1016/j.jfoodeng.2018.04.022.**

Standard operating protocols (SOPs):

Enzymatic determination of cyanhydric acid
Colorimetric determination of amylose content in cassava starches
Enzymatic determination of total starch
Laboratory scale extraction of cassava starch
Determination of post-harvest physiological deterioration of cassava
Determination of starch paste clarity
Boiling cassava: determination of cooking time and texture of cassava roots

PARTNER Gaps & Constraints faced

Several projects on cassava post-harvest quality run in parallel at CIAT, which optimizes our use of resources by enabling synergies (e.g. shared fields and planting materials) and economies of scale. One challenge is to plan the yearly calendar of planting and harvests, so that the activities of all the projects, including RTBfoods, can be carried out timely and successfully, while also leaving flexibility to accommodate unplanned activities that arise from time to time.

Our practice to address this is to keep strong links between the field operation team and the post-harvest team, including daily communications during periods of harvest, in order to anticipate and address immediately any issue with harvests and post-harvest characterizations and analyses.

PARTNER Perspective & Internal organization for Period 2

In Period 2, we will continue the activities of WP2 and WP3 to produce biophysical characterization data and NIRS spectra of fresh and boiled cassava roots, and feed the database for NIRS calibrations. The texture protocol developed during Period 1 will be revised and updated to increase accuracy and improve the chances of identifying correlations with NIRS.

Further exploratory research will be conducted on the usefulness of MIRS to characterize cell wall materials and seek correlations with texture of boiled cassava, in complement to NIRS characterizations.

For WP4, the first crossings of genotypes with various cooking qualities will be conducted in the first quarter. The seeds will be collected and planted by end of 2019, and the characterization of heritability of cooking traits in F1 is expected in Period 3.