Medium-Throughput methods for Screening and Selection:

Predicting Cooking Quality of Boiled Cassava

ISTRC-AB symposium 20-24/09/2021

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Alliance of Bioversity & CIAT / CIRAD

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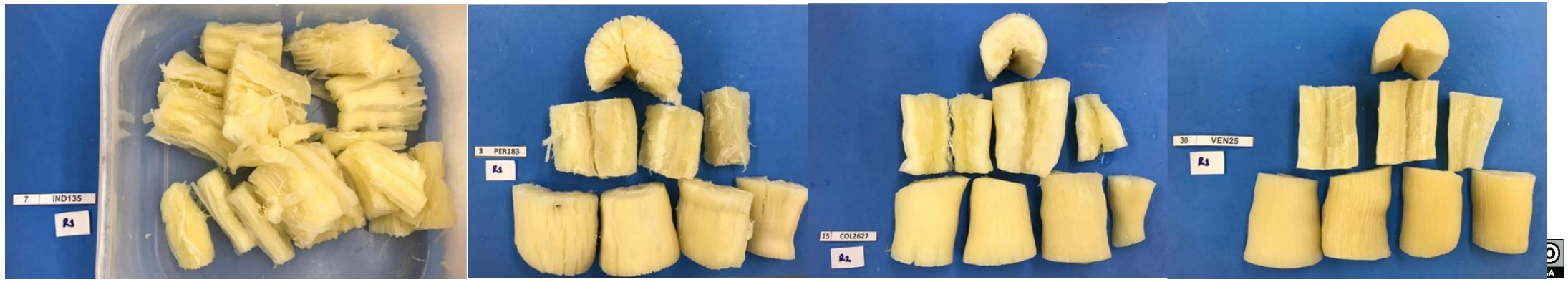
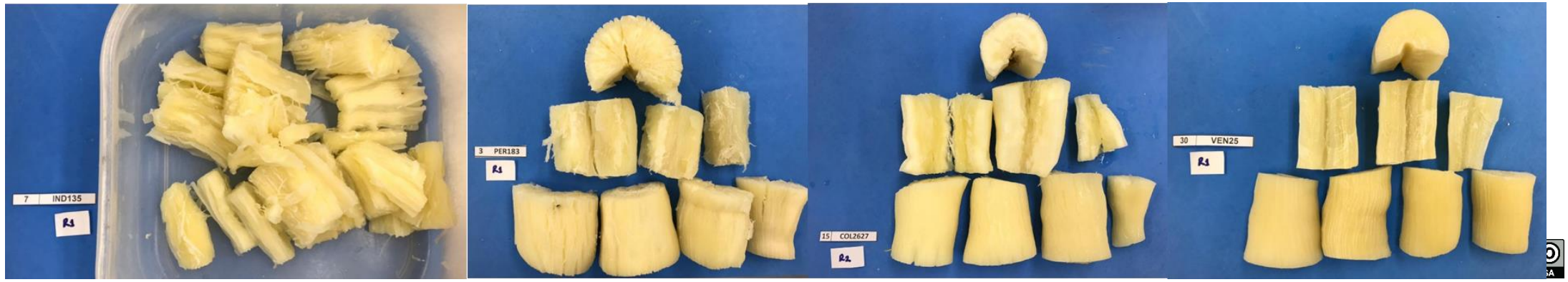
Outline

- **Quality traits** are time consuming to evaluate for breeding and selection.
- Typically, they are not part of routine screening of large numbers of clones.
- Screening focuses on agronomic traits: Yields, tolerance to pests and diseases, plant architecture, etc.
- Nevertheless, there is increasing recognition that **quality traits are important for long-term adoption** of improved varieties.
- → Case study of boiled cassava.



Outline

- **Cooking quality** is an important acceptability criteria for boiled cassava, including cooking time and texture perception (softness, etc.).
  - Desirable: Short cooking time, associated with soft texture
- Current methods are time-consuming, up to 60 min/sample.
- **Faster methods are needed** to integrate cooking quality criteria in the selection process and increase adoption rates.
- **Water absorption (WAB)** is faster (30min), repeatable and can predict **cooking time**.
- **NIRS** is even faster (5 min) and can classify clones into short- and long-cooking groups.



RTB foods in a Nutshell

Research Partners

Nigeria
- NRCRI • IITA
- Bowen University

Uganda
- NaCRRI • NARL
- Bioversity • CIP • IITA

Benin
- UAC-FSA • IITA

Cameroon
- CARBAP • IITA • ENSAI

Côte d'Ivoire
- CNRA

Colombia
- CIAT

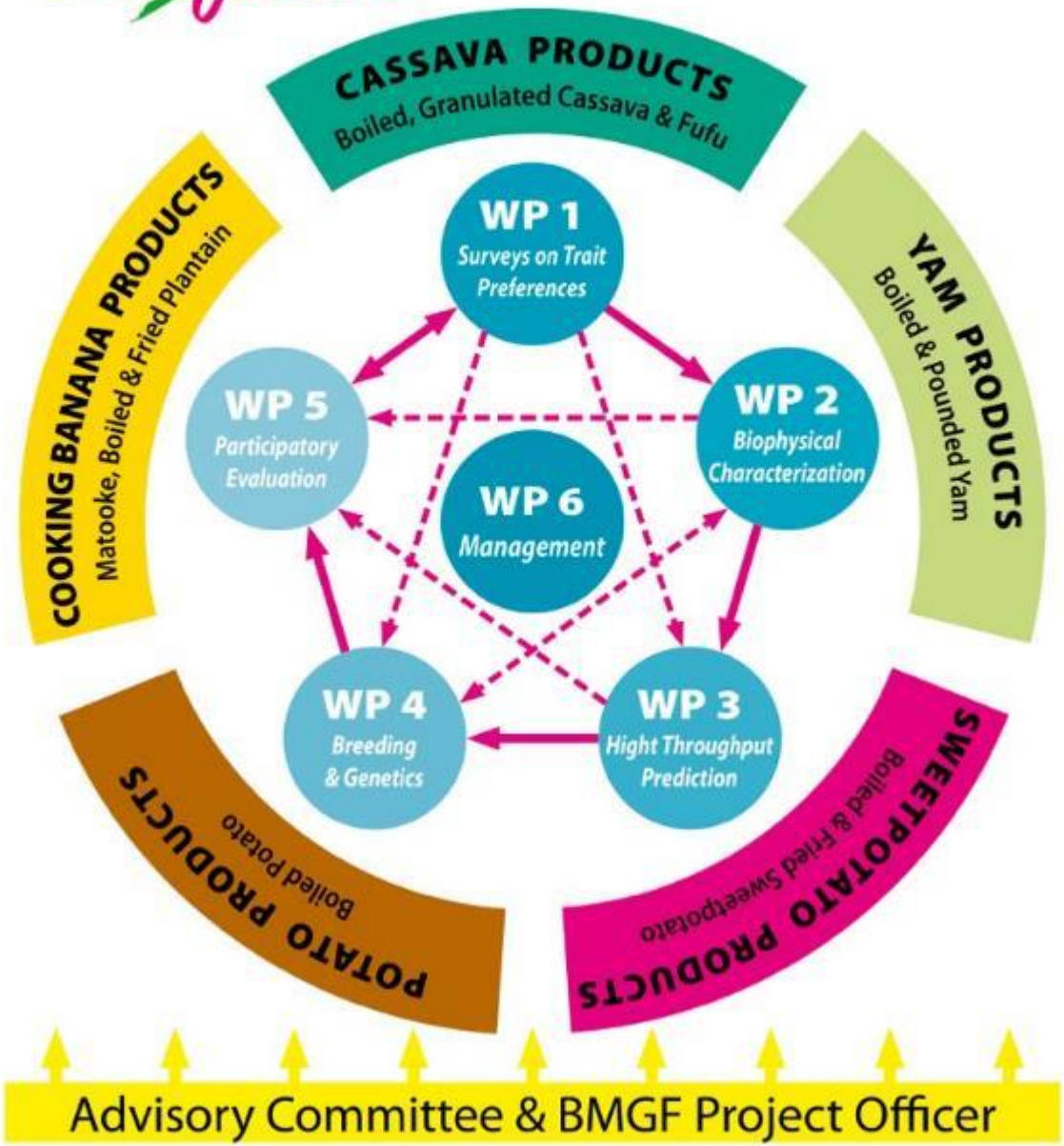
France
- CIRAD • INRAé • Bioversity

USA
- Cornell University – BTI

UK
- JHI • NRI

Partners Projects

- CRP-RTB
- NextGen
- AfricaYam
- SweetGains
- ABBB
- Harvest +



Stakeholders

- Consumers
- Processors
- Local Seed Providers

Countries

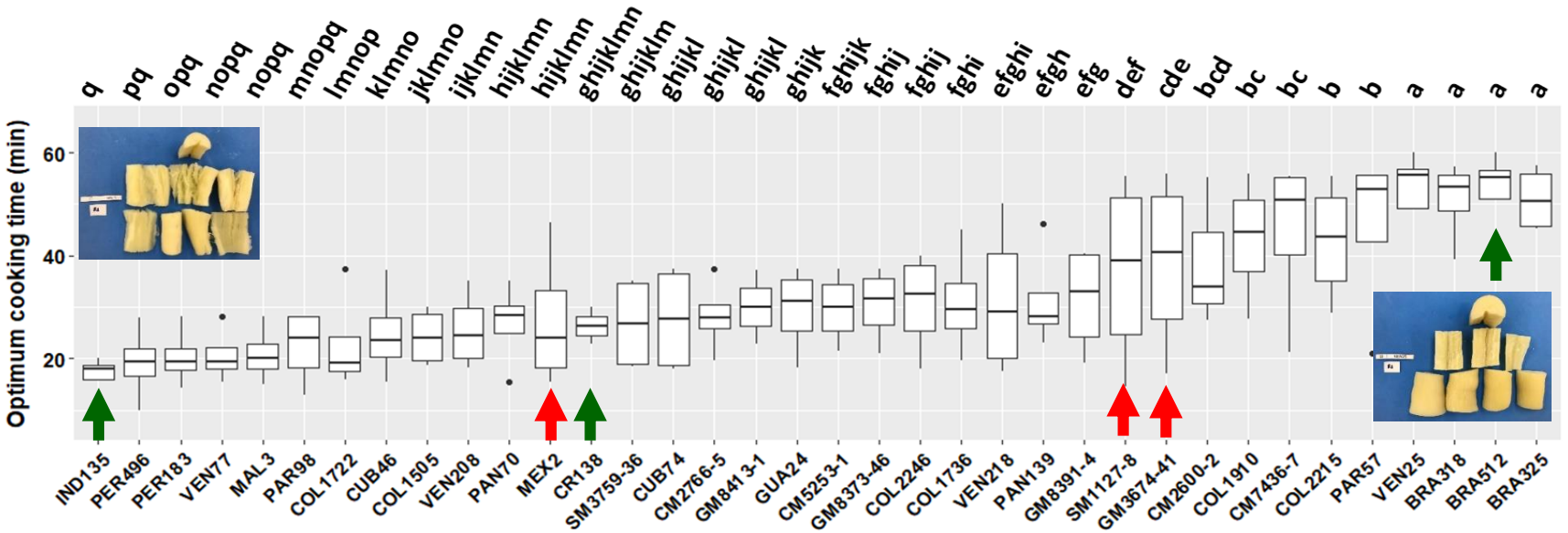
Target Countries

- Benin
- Côte d'Ivoire
- Cameroon
- Nigeria
- Uganda

Spillover Countries

- Colombia
- Ghana
- Kenya
- Mozambique
- Tanzania

Variation of Cooking Time in a Diverse Panel

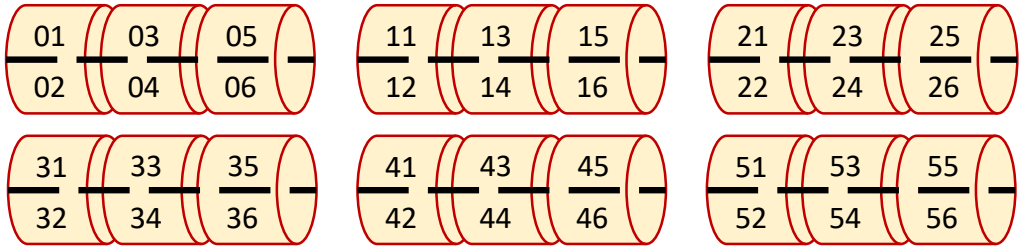


Cooking time of 36 genotypes harvested at 4 different ages (8 to 11 months)

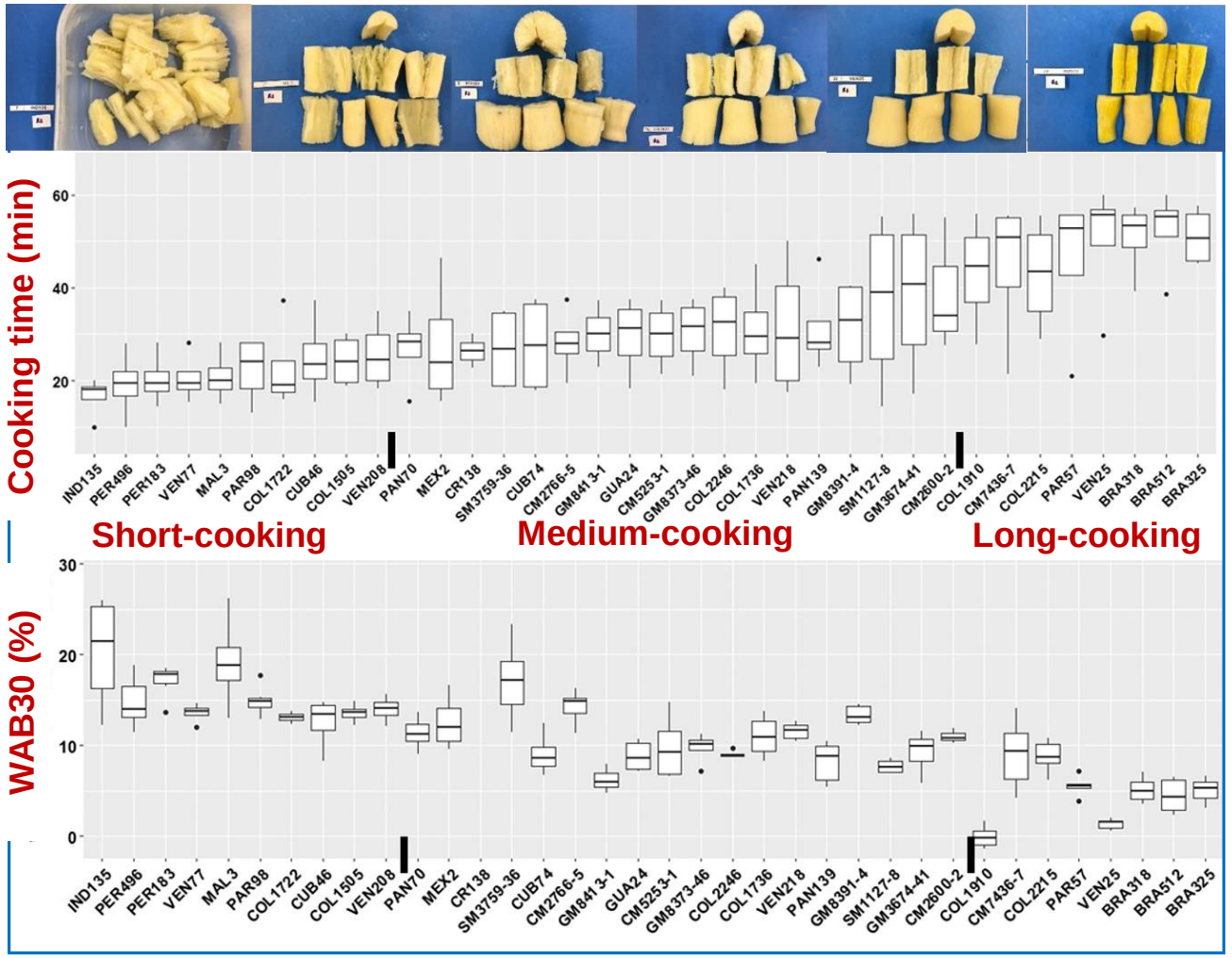
- Some clones are **stable** and predictable in cooking time (CT), but others are highly **variable**.
- Short-cooking clones also tend to be **softer**.
- CT is a key acceptability criteria: Cassava should not take too long to cook!
- Landraces for boiled cassava cook in 15-30 minutes (Colombia)
- → **Target for breeding**: Less than 30 minutes (Colombia)

Evaluation of Cooking Time

- **Conventional method** by prodding pieces with a fork until soft, and recording the time.
  - Slow, up to 60 min for long-cooking genotypes.
  - Somewhat subjective / operator effect.
  - Requires individual evaluation of several pieces, then calculation of average.
- Need faster, more objective method
- → Water absorption during boiling
- → NIRS

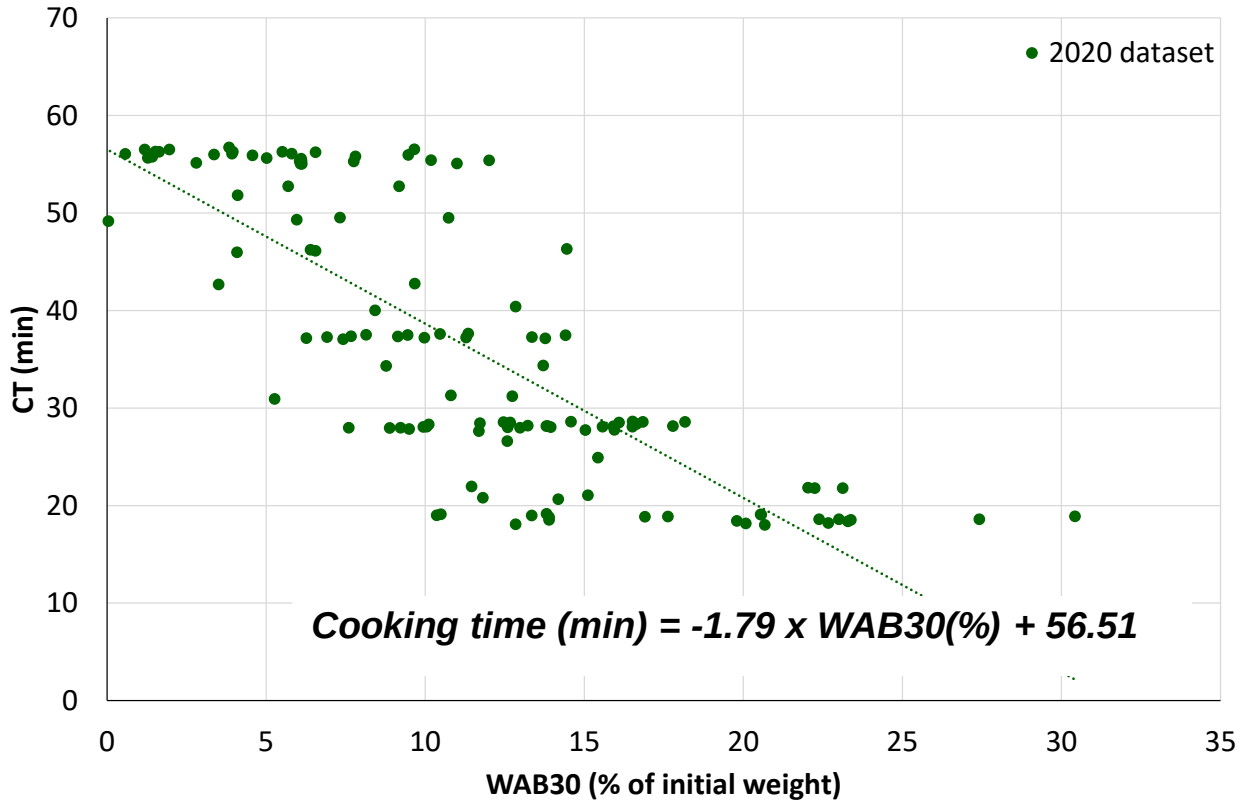


Water Absorption Correlates with Cooking Time



- Diversity of cooking times and water absorptions among cassava genotypes
- **Short**-cooking genotypes tend to have **high** water absorption, and vice-versa.

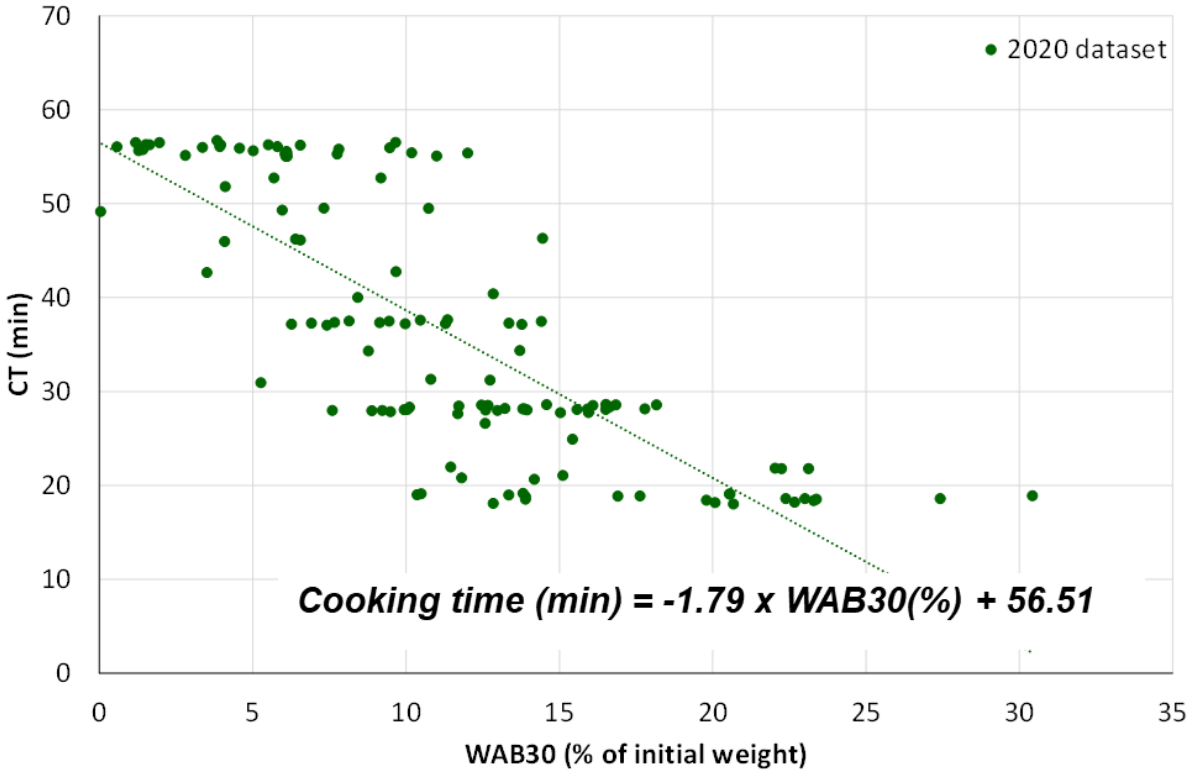
High Correlation between WAB and CT

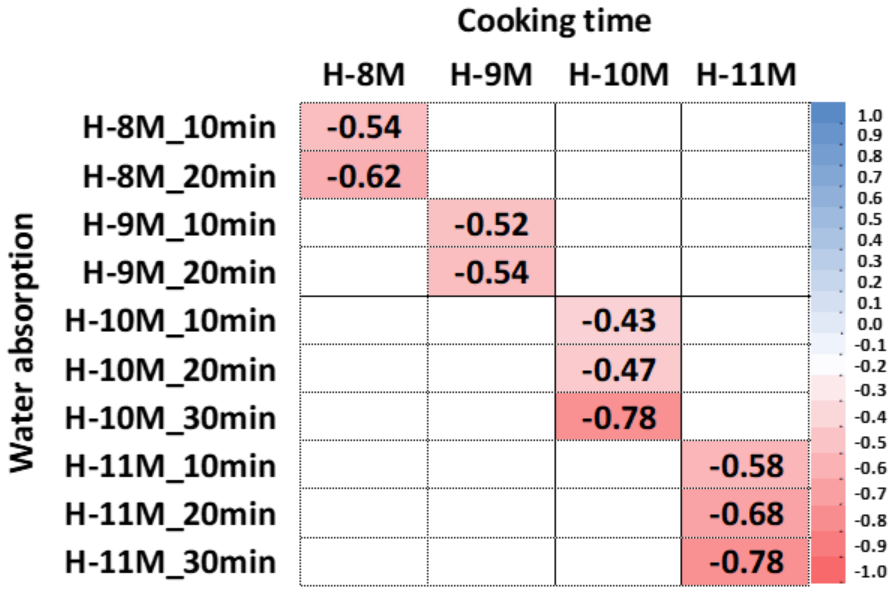


Dataset from Dec. 2019 – Jan. 2020 harvests of 36 genotypes

- **Water absorption** at 30' shows significant correlation with **cooking time (r^2 = 0.63).**

WAB is more discriminant at 30 min cooking





- **WAB30: r = -0.78**
- **WAB20: r = -0.47 to -0.68**
- **WAB10: r = -0.43 to -0.54**

Water absorption at 30 min shows better correlation with **cooking time.**

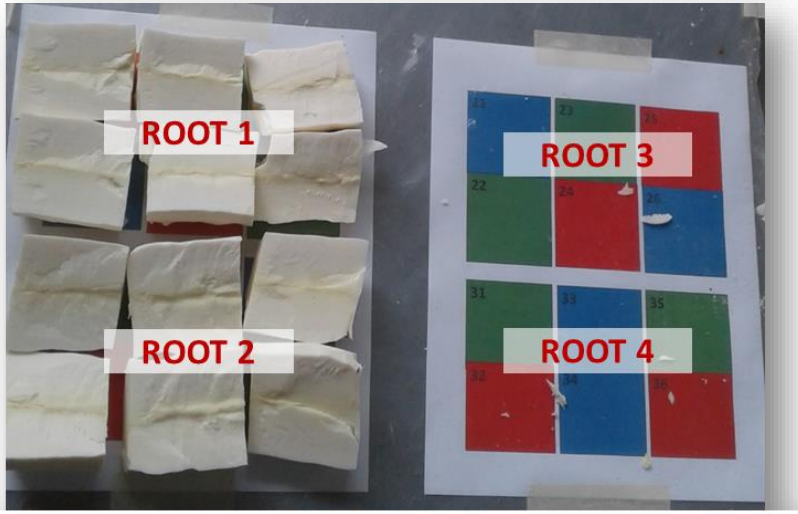
Water Absorption Protocol

International Journal of Food Science and Technology 2021, 56, 1193–1205

Original article

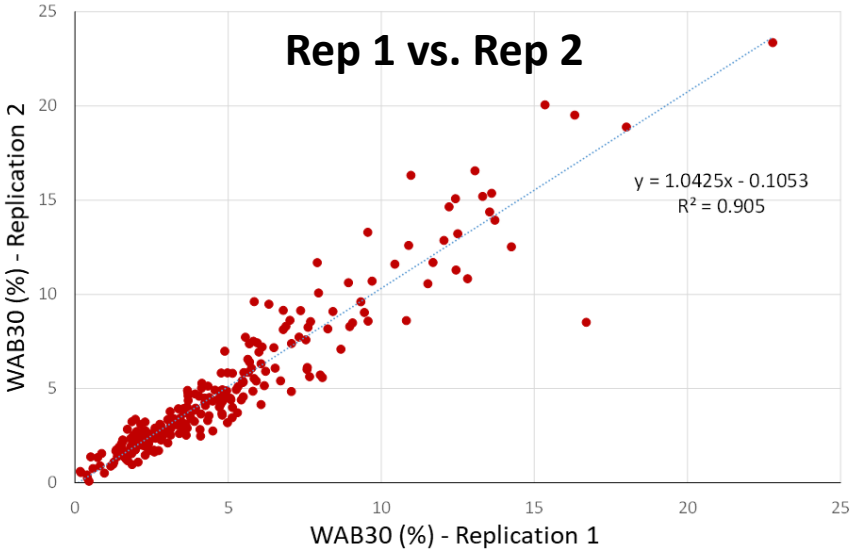
Correlation of cooking time with water absorption and changes in relative density during boiling of cassava roots

Thierry Tran,[1,2,3] Xiaofei Zhang,[1] Hernan Ceballos,[1]* Jhon L. Moreno,[1] Jorge Luna,[1] Andrés Escobar,[1] Nelson Morante,[1] John Belalcazar,[1] Luis A. Becerra[1] & Dominique Dufour[1,3,4]



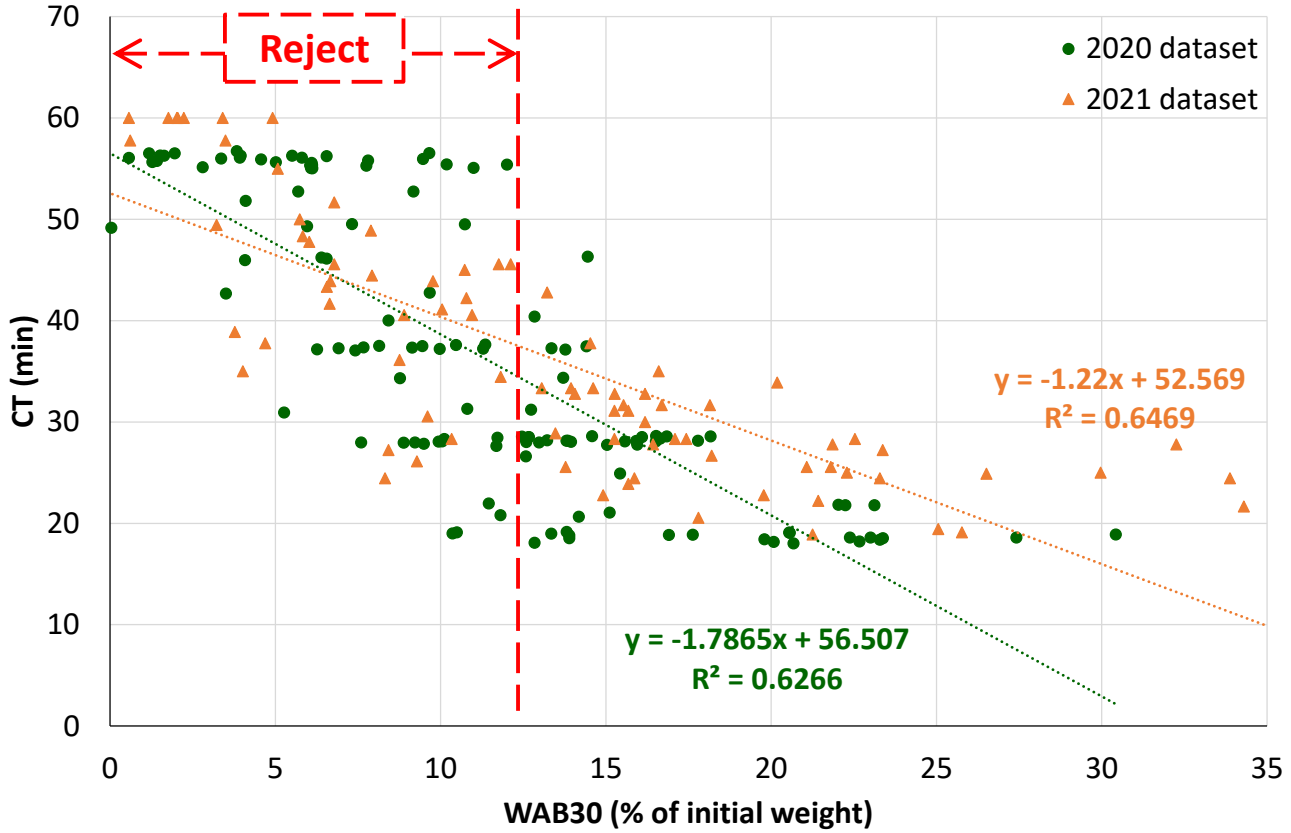
Half-cylinder pieces 6cm long and at least 5cm ∅

- **8 pieces** from 4 to 6 different roots mixed and boiled together.
- Record the weight before boiling (t = 0') and after 30 minutes.
- **WAB30** = Change in weight between t=0' and t=30', expressed as % of weight at t=0'



- **Faster** than fork method: 30 min for all genotypes.
- **Simple** weight measurement, no subjectivity.
- **Stable**: Evaluation of several pieces together, reducing variability.
- **Repeatable**: R^2 = 0.91 between replications
- *Tran et al., 2021. Correlation of cooking time with water absorption and changes in relative density during boiling of cassava roots. International Journal of Food Science and Technology.* https://doi.org/10.1111/ijfs.14769

Replications over two years confirm the correlation



Cooking time (min) = -1.79 x WAB30(%) + 56.51

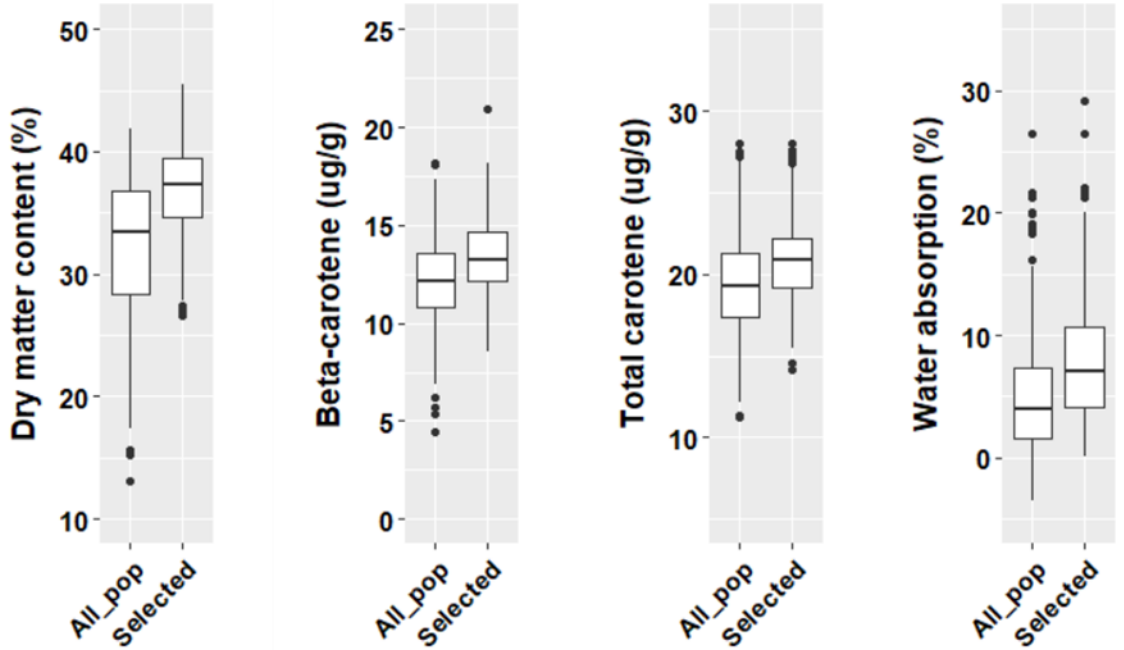
Combined 2020+2021 dataset:

Cooking time (min) = -1.46 x WAB30(%) + 53.98

- **Dataset from Jan.-March 2021** confirms the stability of the correlation over 2 years
- Correlation stable for different ages of the plants at harvest (9 to 11 months)
- Able to screen out long-cooking genotypes, for which the correlation can be considered linear.
- 50 samples/day

Implement Water Absorption in Breeding

- Selection of short-cooking clones among F1C1 **biofortified cassava** at CIAT.
  - Population: F1C1 with 3196 clones.
  - Selected: 389 clones advanced to CET.
  - 4 selection criteria: WAB, DM, BCC, TCC.
- Evaluation of the RTBfoods progeny for the study of **inheritance of cooking quality traits (**February-March 2021).



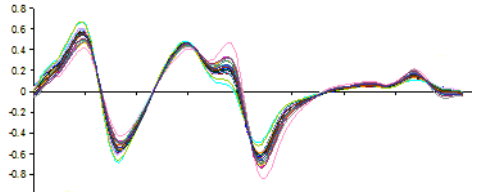
High Throughput Phenotyping using Near Infrared Spectroscopy (NIRS)

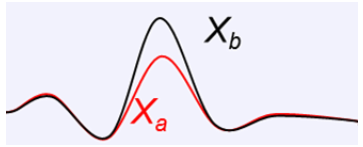
Genotype evaluation for breeding

Fresh samples

NIRS phenotyping

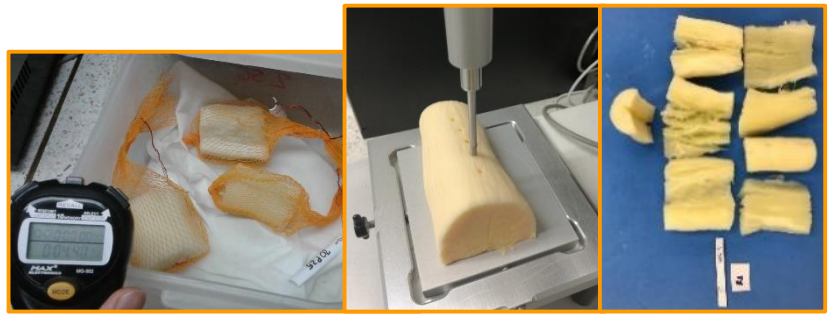
NIRS spectra as fingerprints





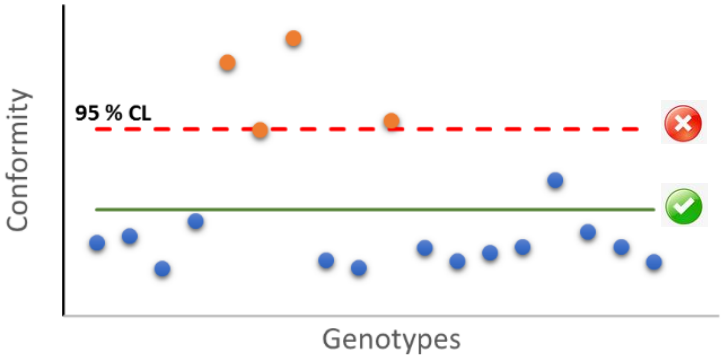
Patterns recognition

Analysis time: 5 min/sample



Conventional biophysical phenotyping

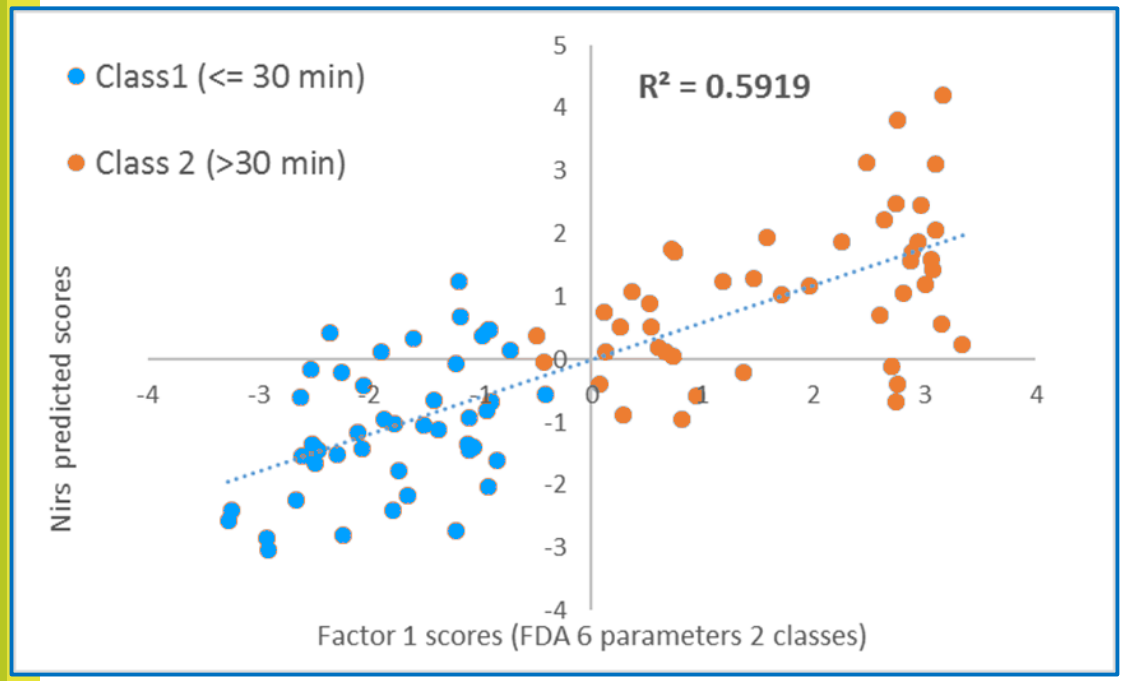
Analysis time: 15-60 min/sample

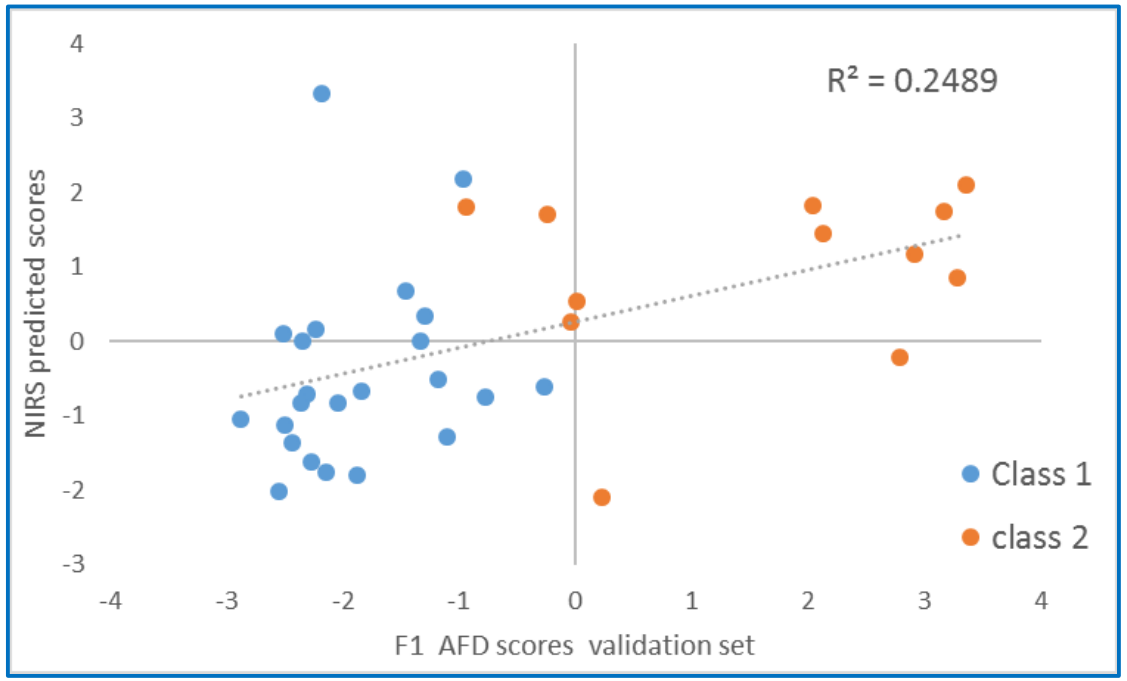


Prediction and screening of desirable food quality traits

High throughput method for cooking time of boiled cassava by NIRS

Classification of genotypes into two classes: ≤ 30 min (C1) and > 30 min (C2)





F1 scores vs predicted scores **for the learning set**

F1 scores vs predicted scores **for the validation set**

Overall 80% correct prediction.
1st demonstration that NIRS can predict quality traits

From \ To	C1	C2	Total	% correct
C1	19	4	23	82.6%
C2	3	9	12	75.0%
Total	24	11	35	80.0%

Acknowledgements

CIAT Cassava Program

Post-harvest Quality Lab team

Field team

RTB Flagship 4 - CA4.2

John BELALCAZAR, Larry MORENO, Jorge LUNA, Alejandra OSPINA, Andrés ESCOBAR, Cristian DUARTE, Sandra SALAZAR, Nelson MORANTE, Hernan CEBALLOS, Xiaofei ZHANG, Dominique DUFOUR, Luis Augusto BECERRA

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Alliance

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AGRICULTURAL RESEARCH FOR DEVELOPMENT

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RESEARCH PROGRAM ON

Roots, Tubers and Bananas