Boiled Sweetpotato

Key Findings from RTBfoods in Period 2

Robert MWANGA, CIP, Uganda

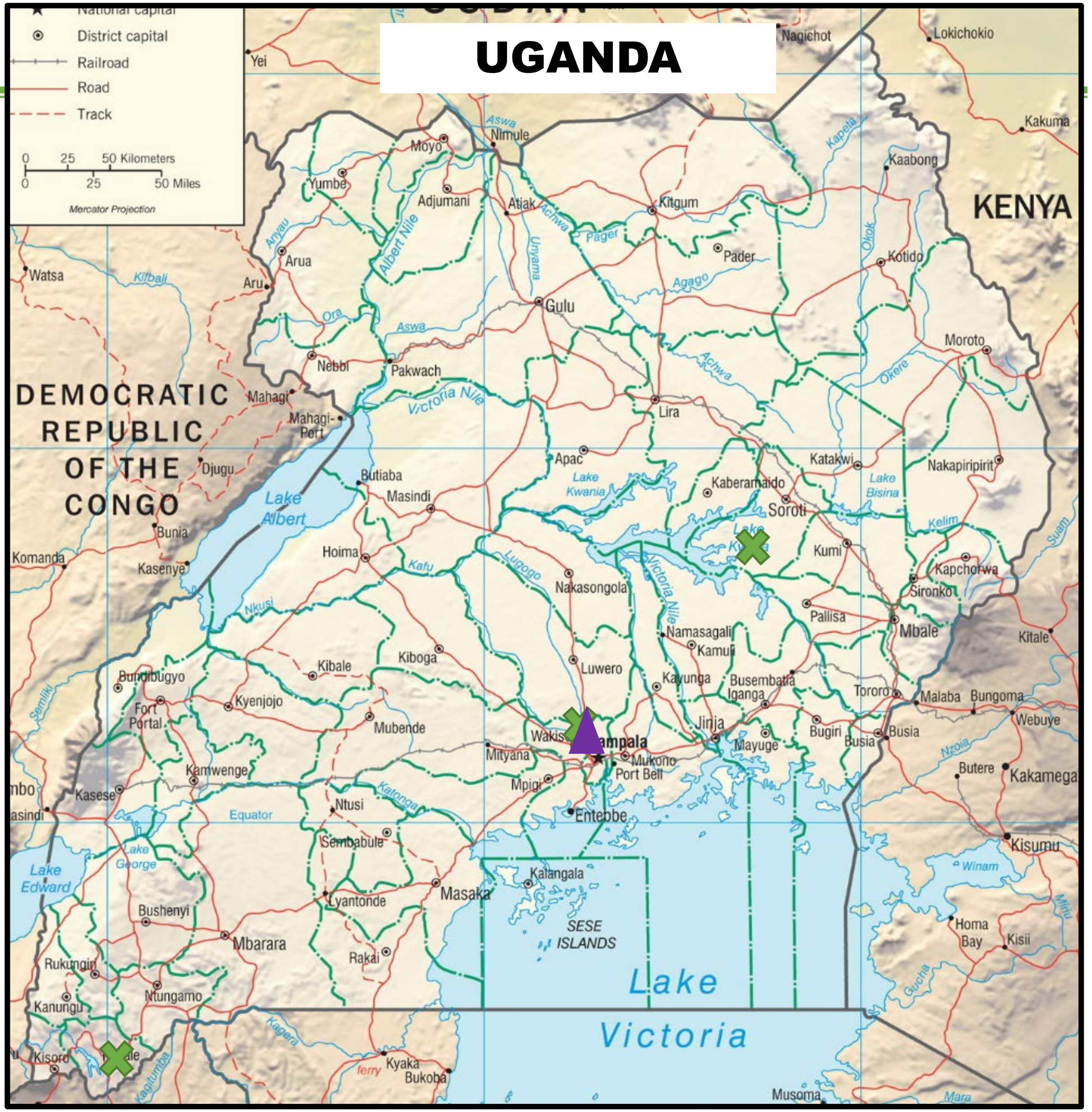
Jolien SWANCKAERT, CIP, Uganda

Other Contributing Scientists (listed on last slides of the presentation)

RTBfoods 2nd Annual Meeting, Kampala, Uganda, 3-7 Feb. 2020

Countries of Activity Implementation

- WP1-Act.3 Surveys
- WP1-Act.4 Processing Diagnosis
- WP1-Act.5 Consumer Testing
- WP2/WP3 Lab.
- WP4 Fields
- WP5 On-Farm /Advanced Trials



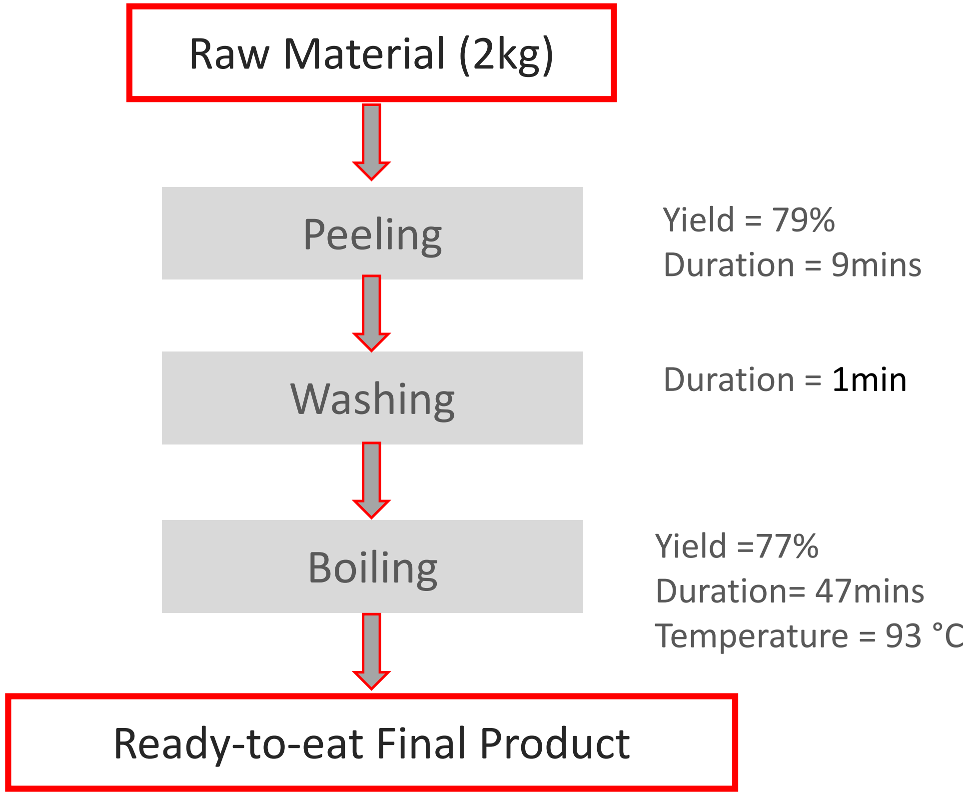
Institutes & Main Scientists Involved

- **CIP** – Uganda, Kenya & Peru (S. Mayanja, J. Swanckaert, M. Nakitto, M. Moyo, L. Banda, T. zum Felde, R. Mwanga)
- **JHI** – UK (M. Taylor)
- **NARL** – Uganda (K. Nowakunda, E. Khakasa, M. Matovu)
- **NCSU** – USA (S. Johanningsmeier)

WP1

Process Description

- Flowsheet Diagram of the Process (Act. 3 &/or Act. 4 if available)
- Key Physical Parameters measured: yield & duration at each step, cooking temperature, dry matter (Act. 4)



List of Quality Characteristics of the **Raw Material**

Rank	Most Preferred	Least Preferred
1	Big root	Watery
2	Smooth skin	Rough skin
3	Hard root	Fibrous
4	Good smell	Rotten
5	Sweet taste	Tasteless

- Men and women agreed on the top three characteristics, however, the order of prioritisation was different.
- Characteristics which only women mentioned were; sweet taste; and small root, tasteless while men mentioned; no damage to skin; and rotten.
- Respondents in Kamwenge and Lira mentioned the same characteristics, but the order of prioritisation was different.
- Characteristics which were only mentioned in Lira were; no fibres; and rotten, shapeless.

List of Quality Characteristics of the **Raw Material** during **Processing**

Rank	Most Preferred	Least Preferred
1	Sweet taste	Bad appearance (cracked skin)
2	Good smell	Small size
3	Hard root	Rough skin
4	Easy to peel	Bad (pale) skin colour
5	Good appearance (no spots)	Rotten root

- Men and women agreed on good smell, among the top three characteristics.
- Characteristics which only women mentioned were: hard root, good appearance (no spots); and soft while men mentioned: sappy, low water content, ease of cooking; and bad skin colour.
- Some characteristics were mentioned in both regions, but were prioritised differently. These include: sweet taste, good smell; and small size, bad appearance.
- Characteristics unique to Kamwenge were: hard root, good appearance (no spots), good texture; and soft, infected roots and tasteless. Those unique to Lira were: easy to peel, sappy, smooth peel, good colour; and rough skin, bad skin colour, rotten.

List of Quality Characteristics of the **Raw** or **Ready-to-Eat Final Product**

Rank	Most Preferred	Least Preferred
1	Sweet taste	Watery
2	Good smell	Tasteless
3	Mealy	Soft
4	Firm	Not sweet
5	Not fibrous	Bitter

- Men and women agreed on the top three characteristics.
- Characteristics which only women mentioned were: watery, fibrous, bitter, while men mentioned: attractive colour; and bad taste, bad smell, not sweet.
- Characteristics unique to Lira are: nice colour, sappy taste in the mouth and good appearance.
- Characteristics which were only mentisoned in Lira were: well cooked; and bitter, not sweet while; not fibrous; and fibrous, bad smell were mentioned in Kamwenge..

Main Preferred & Less Preferred Varieties

Most Preferred varieties	Least Preferred varieties
Okonyonedo (L)	Dwe acel (L)
Naspot 8 (N)	Esseya (L)
Arakaraka (L)	Anamoito (L)
Otada (Lira Lira) (L)	Oleke (L)
Kakamega (L)	Agoba (L)
Vitta (N)	Penninah (L)
Rwetuma (L)	Kabode (N)
Kiribwamukwe (L)	Kakazikamalyo (L)

- Improved/ new varieties such as Naspot 8 were mostly preffered by women and respondents from Kamwenge.
- Local varieties from Lira were ranked highly.

WP2

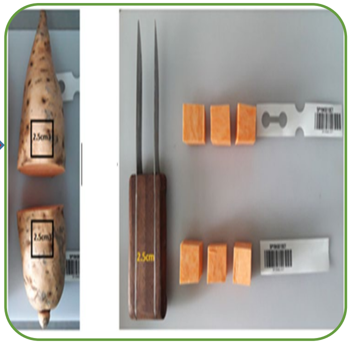
Characterization of Cooking/Processing Ability

Key Achievements

1. Developed and submitted an SOP (*Release 1*) for determination of cooking time and texture in boiled sweetpotato

SORTING

CUTTING



PACKING/ LABELLING

OCT

TEXTURE: WATER BATH

2. Texture analysis of selected clones from the MDP trial over two seasons (Sep and Nov 2019)

TEXTURE ANALYSIS

Cooking time and texture analysis in selected MDP varieties

Trial	Kabale	Serere
Number of genotypes	65	75
Cooking time	12 – 60 min	12 – 45 min
% Variation (cv. pop)	45.32	32.14
Texture (firmness, N)	-	10.7 - 39.02
% Variation (cv.pop)	-	31.47
% Variation (cv.geno)	-	1.70 – 54.98%

Cooking time and texture analysis in selected MDP varieties

Trial	Kabale	Serere
Number of genotypes	65	75
Cooking time	12 – 60 min	12 – 45 min
% Variation (cv. pop)	45.32	32.14
Texture (firmness, N)	-	10.7 - 39.02
% Variation (cv.pop)	-	31.47
% Variation (cv.geno)	-	1.70 – 54.98%

Poor/no correlation between cooking time and dry matter in both Kabale (R2= 0.056) and Serere clones (R2 = 0.001).

Cooking time and texture analysis in selected MDP varieties

Trial	Kabale	Serere
Number of genotypes	65	75
Cooking time	12 – 60 min	12 – 45 min
% Variation (cv. pop)	45.32	32.14
Texture (firmness, N)	-	10.7 - 39.02
% Variation (cv.pop)	-	31.47
% Variation (cv.geno)	-	1.70 – 54.98%

Poor/no correlation between cooking time and dry matter in both Kabale (R^2= 0.056) and Serere clones (R^2 = 0.001).

Poor/no correlation between texture and dry matter in Serere harvest (R^2= 0.198)

Sensory Profiling of Sweetpotato Varieties
Key achievements

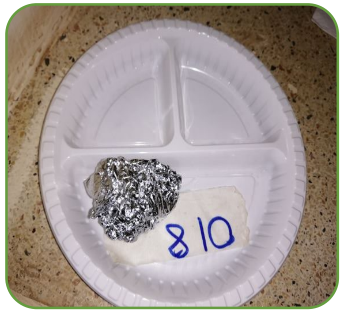
1. Developed an **SOP** for sample preparation for sensory evaluation

SELECTION & CODING

CUTTING

COOKING

PRESENTATION



2. Developed a **lexicon** for boiled sweetpotato
   - Generated an initial list of descriptors and revised it
   - vocabulary complete with clear definitions and structured scales with references
3. Developed systematic **workflow** for sensory analysis to standardise assessment
4. **Panel training** in application of vocabulary and scales
   - To ensure validity, homogeneity among panelists and repeatability of individual panelists

Changes in list of descriptors

Category	Terms in initial list of descriptors	Terms in revised list of descriptors
Appearance	Orange color intensity, uniformity of color, degree of translucency, fibrous appearance (=4)	Orange color intensity, uniformity of color, degree of translucency, fibrous appearance (=4)
Aroma	Sweetpotato, pumpkin, cooked carrot, floral (=4)	Sweetpotato, pumpkin, cooked carrot, floral (=4)
Odour	Sweetpotato, caramel, pumpkin, boiled potato, boiled beans, yam, cooked banana leaves, boiled corn, green, herbal, pungent/acidic/rotting sweetpotato (=12)	Sweetpotato, caramel, pumpkin, off-odour (=4)
Taste	Sweet, sour, bitter (=3)	Sweet, sour, bitter (=3)
Texture	In mouth: Surface roughness, springiness, fracturability, firmness, crunchiness, moisture release, moisture in mass, adhesiveness, uniformity of texture, cohesiveness, fibrousness, smoothness, rate of breakdown (=13)	In mouth: fracturability, hardness, crunchiness, moisture in mouth, adhesiveness, fibrousness, smoothness, rate of breakdown (=8) By hand: moisture release, cohesiveness, crumbliness (=3)

Traits Dissection to Explore/Explain Biophysical Quality Characteristics

- Proofs of Concepts to explore/explain Processing/Cooking Ability & Other Quality Traits (textural analysis, starch & parietal compounds analysis, image analysis, etc.)

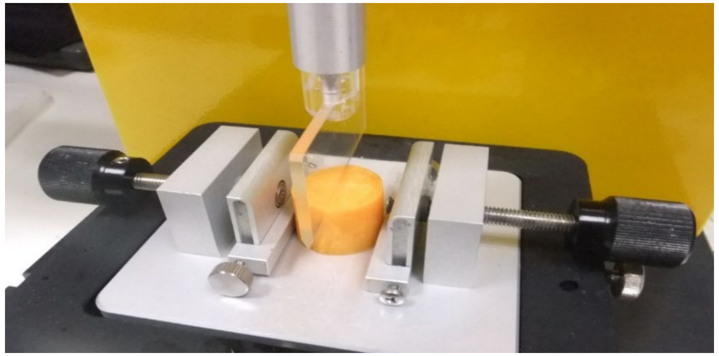
  - Cell wall analysis
    - Cell walls are an important structural component and their degradation/hydrolysis during cooking affects texture
    - Clones with highly contrasting textures will be analysed for cell wall and soluble polysaccharide composition
    - Method has been developed at JHI; the analysis will be done at CIP-Nairobi and JHI

  - Starch analysis
    - Starch content and composition (amylose/amylopectin) as well as gelatinization properties will be analysed
    - In pilot studies at JHI and CIRAD, gelatinization enthalpy and temperature, and amylose content were significantly correlated to measurements of firmness.
    - Starch granule structure will be determined using SEM at South Dakota State University

  - Enzyme analysis
    - Enzymes involved in starch hydrolysis (β amylase) and pectin hydrolysis (pectin methyl esterase)
    - Rate and extent of hydrolysis could correlate with the cooking time and/ or texture
    - Preliminary study at JHI showed no significant correlation, but this will be pursued with clones that have highly contrasting textures both at JHI and CIP-Nairobi

Sweetpotato texture work done at JHI

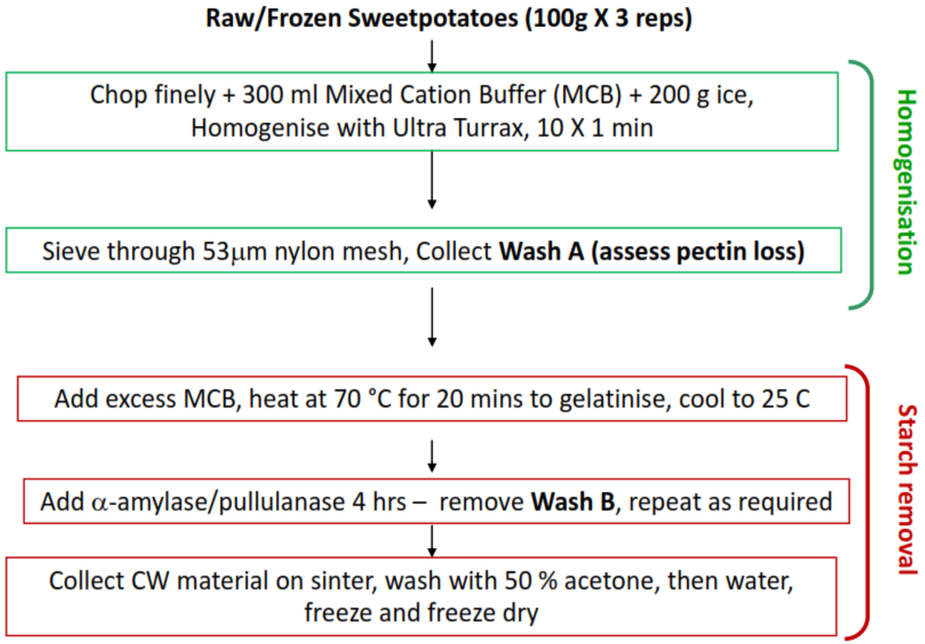
- Several cooking methods were tested to assess variability and reproducibility including steaming and boiling. Boiling and steaming were rejected due to problems with sample orientation, reproducibility and uneven cooking.
- Cooking the sweetpotato roots in sealed plastic bags provided the best temperature control, traceability and high throughput screening.
- A cooking temperature of 85°C for 10 and 20 minutes proved to be optimum for accurately detecting texture differences between genotypes and was validated compared with cooking time measurements by colleagues in Uganda.
- Similar rankings of textural properties were observed in samples cooked at 95°C.
- Data incorporated into sweetpotato texture SOP



Enzyme and DSC analysis done at JHI

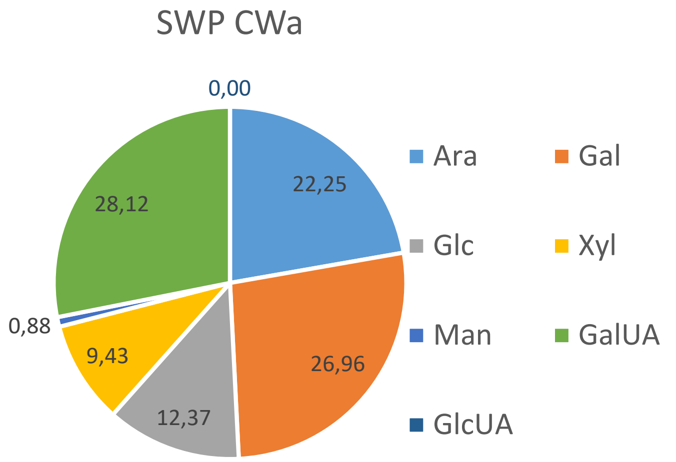
- Pectin Methylesterase – we hypothesise methylated pectin prevents cohesive pectin-Ca^{2+}-pectin interactions between cells. PME activity results in demethylated pectin and so is this correlated with cooking time/texture measurements?
- β-amylase – β-amylase activity breaks down starch to oligomers that can escape from the cell. Higher β-amylase activity will result in more starch breakdown, reduced starch swelling pressure, and slower cooking time and/or firmer texture. Is there a correlation between β-amylase activity and cooking time/texture ?
- Enzymes assays were developed and applied to 15 genotypes supplied by CIP-SSA – no significant correlations
- DSC analysis – was conducted in collaboration between JHI and Mestres, CIRAD - Multiple regression analysis showed that starch characteristics (gelatinization enthalpy and temperature and amylose content) were significantly correlated to measurements of firmness after 20 minutes of cooking

Cell wall preparation and composition
Analysis done at JHI

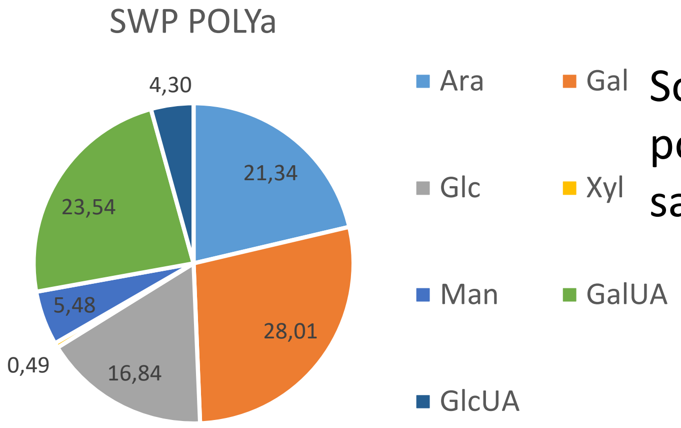


Method for cell wall analysis

The major sugar component in both the polysaccharide and cell wall material is GalUA, galacturonic acid. The two samples also have arabinose (Ara), galactose (Gal), glucose (Glc) and the cell wall material has higher amounts of xylose (Xyl) whereas the polysaccharide has higher amounts of mannose (Man)



Cell Wall Preparation



Soluble polysaccharide sample

WP3

Progress on NIRS calibration development to predict quality traits (1)

In November 2019, WP3 developed a NIRS workflow in Uganda to scan a diverse set of sweetpotato clones of the MDP in close collaboration with WP2 activities on the same material. Product presentations were:

- **raw fresh (intact and blended)**
- **raw dried**
- **boiled fresh**
- **boiled dried**

WP3 processed and scanned in total 60 diverse sweetpotato clones at NARO facilities which were harvested in Serere/Uganda.

(Harvest and field sampling in Serere were done 3 days before the processing and scanning at NARO started.)

Progress on NIRS calibration development to predict quality traits (2)

- For analysis, 3-4 representative roots per clone were sorted, labeled, and separated.
- Materials were washed, peeled and cut in the middle to be scanned by NIRS as **‘intact’ roots**.

Progress on NIRS calibration development to predict quality traits (3)

- One half of each root was sliced. All slices were mixed and evaluated for DM.
- A subsample was blended and scanned by NIRS again as **raw, blended, fresh** sample**.**
- The sliced and blended material was immediately frozen at -20C, then freeze dried, milled and scanned by NIRS as **raw, dried powder** in Uganda and **<u>Peru</u>.**



Progress on NIRS calibration development to predict quality traits (4)

- The remaining 3-4 half roots were boiled with optimal cooking time.
- All cooked material of each genotypes was mashed together and scanned by NIRS as **fresh boiled** material.
- This material was freeze dried as well, milled and scanned by NIRS as **boiled dried** material in Uganda and **<u>Peru.</u>**




Next steps

- To date, the material (60 raw dried and 60 boiled dried samples) are under wet chemistry reference analysis for NIRS calibration development.
- All 120 samples were shipped to CIAT-Columbia to perform the following analysis: viscosity (raw samples), swelling power and solubility evaluation (raw samples), starch (raw samples), individual sugars (raw and cooked samples), amylose (raw samples).
- Additional 16 samples were selected based on their cooking & texture behavior, DM content and NIRS predictions with available calibrations at CIP to be analyzed at CIRAD for starch characteristics and pectin content and at JHI for PME and b-amylase activity.

(All 120 dried samples processed in Uganda were scanned by NIRS at CIP in **Peru** for future calibration development as well.)


NaCRRI
CIP
Phenotyping trial: Mwanga Diversity Panel (MDP) population
• 2,159 entries, 2 checks
• Single row plot, 1 m x 3 m
• Experimental design: Westcott
• Planted: March 7, 2019
NC STATE UNIVERSITY

WP4

Key Progress in Sweetpotato Breeding for Quality

- Mwanga diversity panel (MDP)
- MDP population: ~ 2000 genotypes from an 8x8 cross (16 parents)
- Developed under the Genomic Tools for Sweetpotato Improvement (GT4SP) project
- Phenotying experiments at three locations in Uganda
- Data collection including:
  - Quality traits on raw roots: flesh color, shape, size
  - Resistance to diseases and pests: SPVD, Alternaria and weevil
  - Yield related traits: storage root yield, foliage yield, number of commerical and non-commercial roots
- Data is captured in SweetpotatoBase
- Roots from Namulonge and Kabale: SOP development in WP2
- Roots from Serere: joint WP2/WP3 activity
- Genotypes are planted again at the three locations, expected harvest in Feb-March 2020

WP5

On-Farm Trials & Evaluation of Advanced Material

- On-farm / Advanced Trials
- Examples of Participatory Evaluations of Pre-released Material

Activities will be carried out in period 3

Conclusion on Perspectives for all WPs

- WP1 Activity 4 & 5 Data Analysis – Consolidation of Final Product Profile
- Interactions WP1 / WP2: How? When? Who?
- Definition of Quality Traits to inform Crop Ontologies (by WP2)
  - New focal point for sweetpotato ontology
- New Spectral Calibrations to be dvped for Quality traits (by WP3)
  - Raw sweetpotato, scanned as a fresh root
  - Raw sweetpotato, scanned after grinding the fresh root
  - Cooked sweetpotato, scanned after boiling and mashing into puree
  - Cooded sweetpotato, scanned after freezedrying the puree
- IJFST Publication: Robert Mwanga


P905
P1135
P1085
P574
P881
P1139
P924
P1087
P680
P862
P573
P332
P331
P258
P825
P227
P189
P639

RTBfoods

WP1 Collaborating Scientists – to be completed

- …..

WP2 Collaborating Scientists – to be completed

- …..

WP3 Collaborating Scientists
– to be completed

- .....

WP4 Collaborating Scientists – to be completed

- …..

NOT TO BE PRESENTED

WP5 Collaborating Scientists – to be completed

- …..