Granulated Cassava: Gari for *eba* in Nigeria

Key Findings from RTBfoods in Period 2

Bela Teeken

for

Busie MAZIYA-DIXON, IITA, Nigeria

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

- **IITA** – Nigeria (B. Teeken, B. Maziya-Dixon, E. Alamu, P. Kulakow, I. Rabbi)
- **NRCRI** – Nigeria (U. Chijioke, T. Madu, M. Ofoeze, C. Egesi)

WP1

WP1 methodology training given by eba team

- Training in Cameroon with Prof. Ndjouenkeu work on gari (Béla Teeken)
- Training at IITA work on fried plantain in Nigeria (Béla Teeken, Esme Stuart)
- Training at IITA team work on pounded and boiled Yam for AfricaYam (Olamide Olaosebikan, Abolore Bello, Adebowale Osunbade, Béla Teeken).









Process Description – Gari for Eba

- **Flowsheet Diagram of the Process**

Raw Cassava roots → Peeling & grating → Fermentation and pressing → Sieving and toasting… →

By hand, machine grating in minutes

From 0 to 5 days

Intermediate product: gari → Rehydration of the gari to eba (adding hot water) → Ready-to-eat Eba

In minutes

- **Key Physical Parameters measured during Activity 4 (weight in kg)**: Fresh roots, Peeled root, Peels, Grated mash, Pressed cake, Sieved out Chaff, Gari weight, Eba weight (gari/water standardized at ratio 1:4 to obtain texture) differences.

Regional differences in processing

WP 1 work in 3 states and a total of 12 communities:

- OSUN (Southwest): **Long fermentation of 4-5 days of fermentation and focus on white gari (no oil added)**

- BENUE (Northcentral): **Moderate fermentation**
  - **1 day for Tiv ethnic group**
  - **2 days for Idoma ethnic group**

  Focus equally on white and yellow gari (with added oil after grating)

- IMO (Southeast)

  Very short fermentation (direct pressing) and focus on yellow gari (oil added after grating) but also white gari is made.

Not many differences between regions and ethnic groups and gender

- Despite these differences no major difference found in the preferred characteristics at each stage of the processing especially for Osun and Benue state. Differences lie in the relative degree that people like their preferred characteristics
  - In Benue and Imo a less sour more stretchy and moderately soft *eba* is preferred.

- Women dominate as processors, but no significant gender differences in preferred characteristics could be found, indicating that earlier found differences (Teeken et al. 2018*) indeed reflect gendered tasks and expertise. In this case everybody interviewed (man or woman) was a processor so differences disappeared.

*Teeken, B., O. Olaosebikan, I. Haleegoah, E. Oladejo, T. Madu, A. Bello, E. Parkes, C. Egesi, P. Kulakow, H. Kirscht and H.A. Tufan. 2018. Cassava trait preferences of men and women farmers in Nigeria: implications for breeding. Economic Botany 72(3), pp. 263–277

List of Quality Characteristics of the **Raw Material** – Gari for Eba

Longer fermentation time OSUN and BENUE states:

	Preferred		Not preferred
1	heavy cassava roots all year round*	1	rotten root
2	not rotten	2	light root
3	low water*	3	woody root
4	white flesh	4	small root
5	big long roots	5	high water content
6	Cassava Stem longevity as planting material		
7	Good canopy cover		

List of Quality Characteristics of the **Raw Material** during **Processing** – Gari for Eba

	Preferred		Not preferred
1	no pulp, mash and cake discolouration at each processing stage and final product/colour retention, white/bright mash and cake.	1	pulp, mash and cake discolouration at each processing stage
2	well dried mash, cake and gari	2	high water in cassava root
3	no lumps (during and after roasting)	3	plenty lumps (during and after roasting),
4	low water in cassava root		
5	gari swelling during toasting		
6	Fast dewatering during pressing		

Not pronounced in Imo, but also prominent in Cameroon

In blue: characteristic not in SoK

List of Quality Characteristics of the **Ready-to-Eat Final Product** – Eba

	Preferred when preparing Eba		Preffered when consuming Eba		Characteristics of bad Eba when consuming
1	swelling gari/eba	1	smoothness	1	paste with lump/chaff/woody/sand
2	easily dissolving	2	drawness	2	bad/black/dark/change colour
3	mouldable	3	soft	3	not mouldable
4	smoothness	4	hold together (coheseviness)	4	not stick together (does not hold shape, crumbles, sacks out), stains hand when eating
5	aroma	5	good taste/ aroma	5	not smooth/has undissolved granules
6	drawing	6	mouldable	6	bad/offensive/unpleasant smell or odour
7	stick together (holding together: cohesiveness)	7	bright colour	7	too hard (not soft)

Example Preferred & Less Preferred Varieties

Preferred	reason	Not preferred	reason
Oko- Iyawo	Stem type suppresses weeds, good sprouting, multiple uses, white gari, early maturing, **in ground storability**	Vitamin A Cassava	To much water, although well poundable
Banada/agric	Early maturing, Big root, White gari, high yield, straight tuber (good to peel)	Akpu	Small roots
Akpu	Easy access to stem, good for all products		
IITA/419	Early maturing, good sprouting		
Arubielu	Intercrop with sweet potato, poundable/mealy		
Wonono	Heavy, high gari yield		
Cotonou	Poundable/mealy, gari yield		

BNARDA/AGRIC, WONONO, VITAMINE A cited in Benue not in Osun, WONONO is mainly cited by men

List of Quality Characteristics of the Raw Material – Gari for Eba

Very short fermentation time IMO state (with also longer dehydration resulting into a harder and more drawing eba)

Preferred		Less preferred	
female	male	female	male
big roots	big roots	Rot on roots	Rot on roots
white	white	Stripes on root	high moisture content
heaviness	heaviness	Foamy root	
maturity	many roots	light weight	
		less shelf life	

List of Quality Characteristics of the Raw Material during Processing – Gari for Eba

Preferred		Non preferred
Female	Male	*Act 4*
Not Floating	Good dough	Burnt gari
Ability to sink	No seed/fibre	bad odour
Drawability	Ability to sink	dark colour
Soft	light gari (weight on palm)	powdery
Attractive colour		rotten taste

Colour of the mash and pulp is not too prominent here !

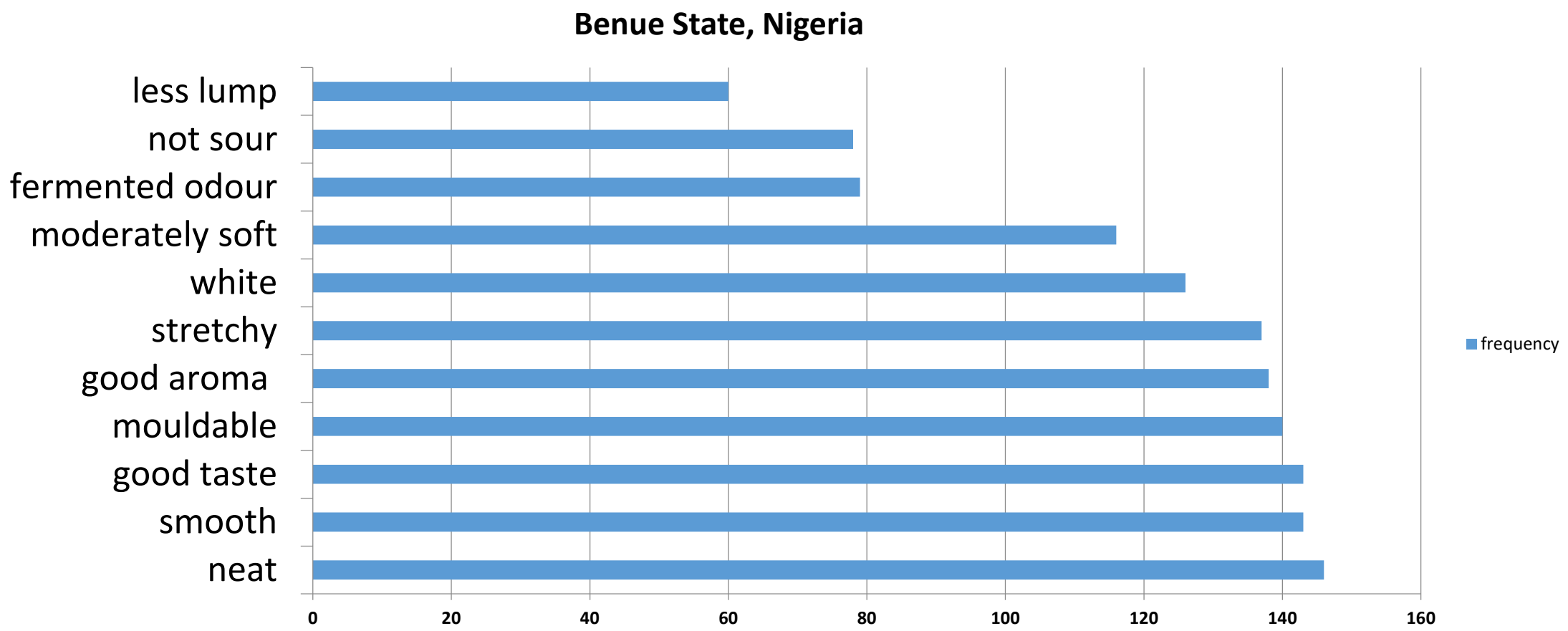
List of Quality Characteristics of the Raw or Ready-to-Eat Final Product – Eba

Preferred		Not-preferred	
Female	**Male**	**Female**	**Male**
Smooth	Drawability	Sticky	Too hard
Easy to swallow	Smooth	Too soft	Sticky
Soft	Yellow colour	Not drawy	Too soft
Not sticky	Easy to swallow	Offensive odour	Not mouldable
Good taste	Not sticky	too hard	
Drawability			

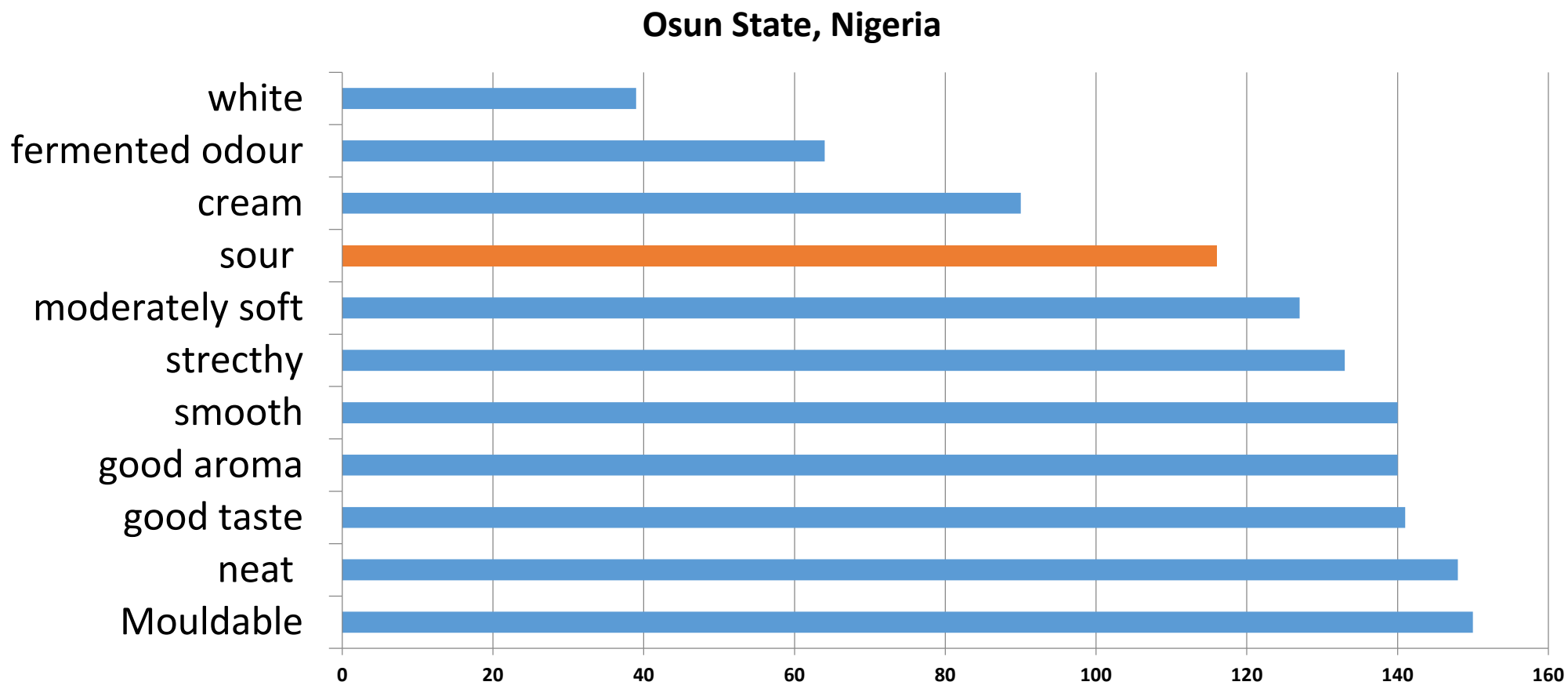
Main Preferred & Less Preferred Varieties

Preferred		Not-Preferred	
Female	**Male**	**Male**	**Female**
Daberechi	Isadep	Durungwo	
Agric	Daberechi	Nwanyibekee	
Imobest	Imobest		
Durungwo	Agric		
Nwaoji	Nwaoji		
Nwaocha	Nwaocha		
Yellow root	yellow root		

Consumer testing: Frequencies of positive characteristics mentioned on most preferred *eba* sample



Consumer testing: Frequencies of positive characteristics mentioned on most preferred *eba* sample



WP2

Characterization of Cooking/Processing Ability

- Fresh (18 NCRP genotypes) and processed (29 genotypes) cassava root samples received from WP1 and 4 for biophysical characterization
- Laboratory analyses mainly focused on functional and quality traits that included;
  - bulk density
  - dispersibility
  - water absorption capacity
  - starch content
  - Total reducing sugar content
- Standard Operating Procedure (SOP) & protocols developed for both fresh and processed samples for both IITA & NRCRI laboratories

Characterization for quality traits;

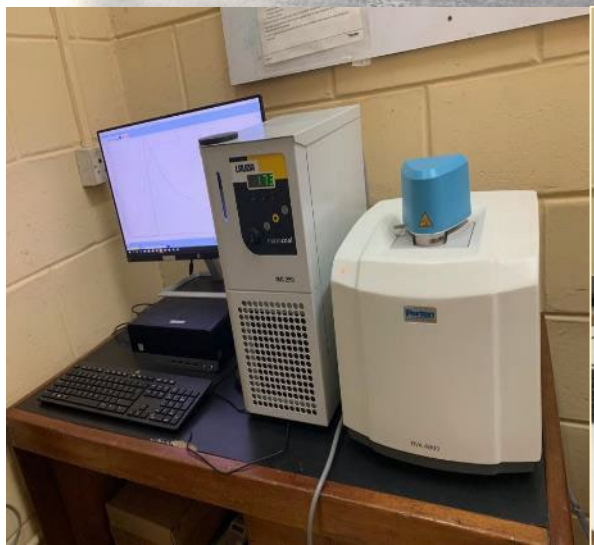
- Laboratory analyses for quality traits characterization included;
  - 72 fresh cassava samples (18 NCRP Genotypes x 2 reps x 2 locations) for dry matter and starch content
  - 130 dried ground cassava (NCRP) flour for proximate composition
  - 129 gari samples (milled and un-milled) were analyzed for functional characteristics
- Resultant data were shared with WP3 team

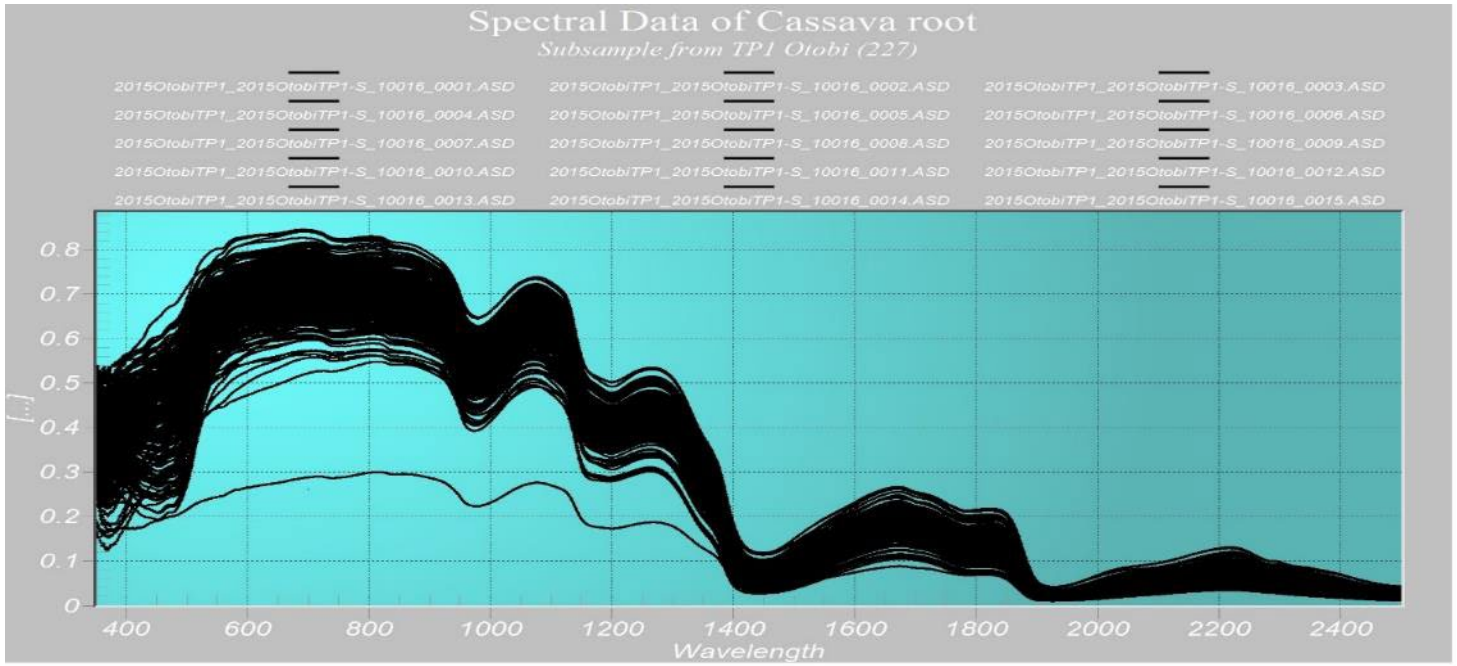
Diversity of processing attributes of Varieties

Descriptor	Sensory attribute(s)	Description
Colour	White	As white as a flip chart paper
	Off- white	As white as soy-milk colour
	Cream colour	Cream in colour, e.g. liquid peak milk
	Light yellow	Colour of an egg yolk
	Yellow	Colour of a yellow maize
Textural quality	Fibrous	Non-Homogenous in appearance
	Lumpy	Forming tiny balls inside Dough
	Softness	Easiness to press e.g. very ripe Papaya
	Stretchability	Chewing gum
Mouldability	Mouldable	Mouldable like clay

Infrastructural and Capacity building – WP2

- Conducted sensory evaluation training for 20 recruited panelists
- Participated in ring test conducted by WP2 leaders: for calibration of WP2 laboratories
- Rapid Visco Analyzer 8400 and a Texture Analyzer procured and installed
- Textural profiling of eba will commence in period 3




Spectral Data of Cassava root
Subsample from TP1 Otobi (227)
2015OtobiTP1_2015OtobiTP1-S_10016_0001.ASD
2015OtobiTP1_2015OtobiTP1-S_10016_0002.ASD
2015OtobiTP1_2015OtobiTP1-S_10016_0003.ASD
2015OtobiTP1_2015OtobiTP1-S_10016_0004.ASD
2015OtobiTP1_2015OtobiTP1-S_10016_0005.ASD
2015OtobiTP1_2015OtobiTP1-S_10016_0006.ASD
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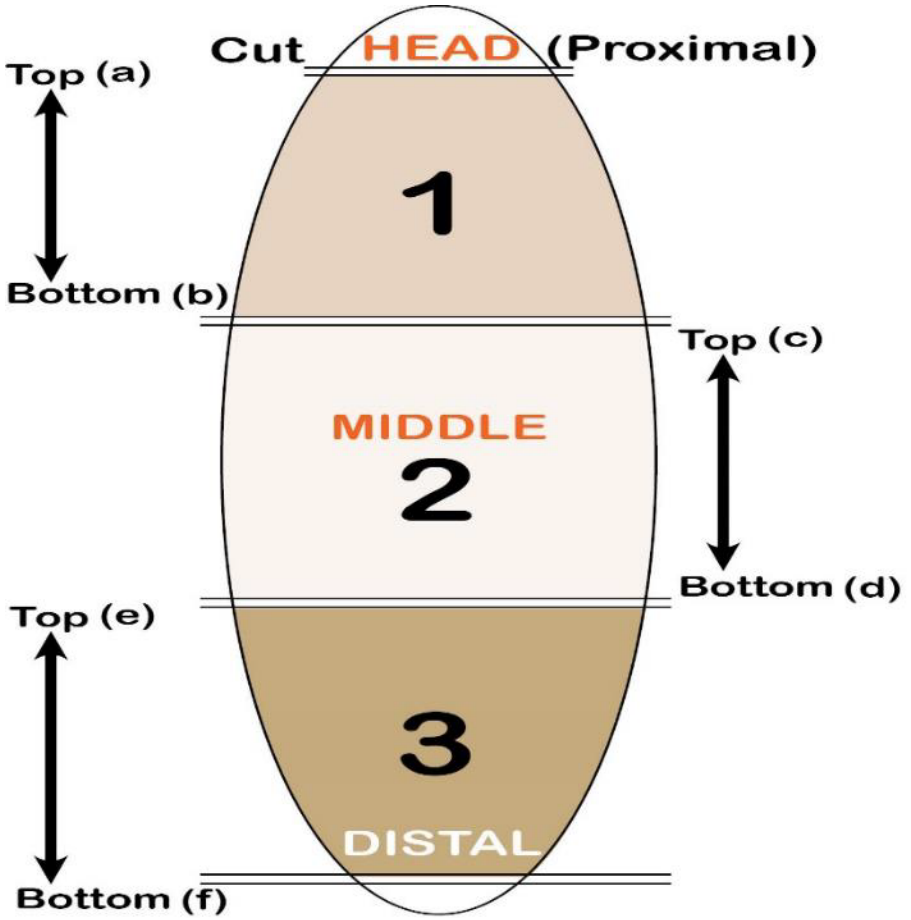
2015OtobiTP1_2015OtobiTP1-S_10016_0014.ASD
2015OtobiTP1_2015OtobiTP1-S_10016_0015.ASD
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
Wavelength


SARAH A1
SARAH B1
SARAH C1
SARAH D1
ELIZABETH B1
ELIZABETH D1

WP3

Development of Calibrations for intact cassava roots

- A total of 233 Spectra readings for intact roots have been generated.
- A total of 233 reference values on DM were used
- A calibration model for Dry matter (DM) for intact root developed and validated.
- Preliminary results
  - ***Coefficient of determination in calibration*** $R^2_{Cal} = 0.75$
  - ***Coefficient of determination in prediction*** $R^2_{pre} = 0.77$
  - ***Further work to improve the calibration is ongoing***

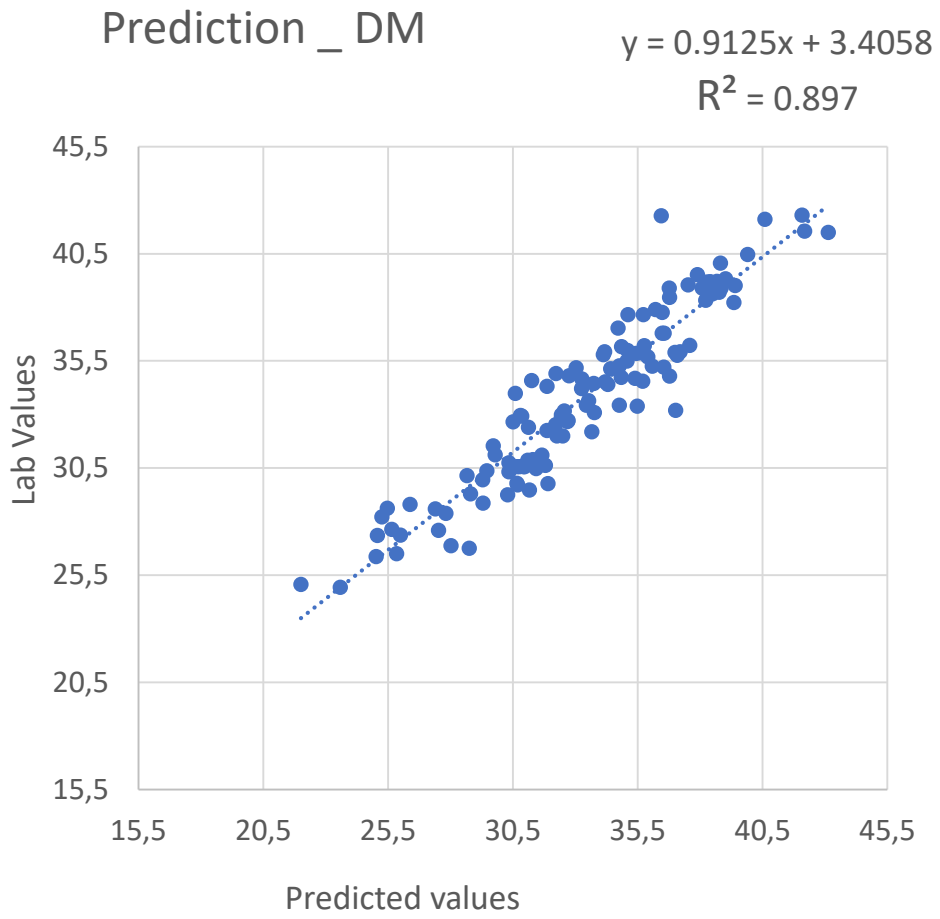


Development of Calibrations for dry matter – content for fresh cassava roots (blended)

- A calibration model for DM for fresh cassava roots (blended) has been developed and validated.
- A total of 144 Spectra used
- 144 reference lab values generated from WP2 were used for calibration
- Preliminary results
- ***Coefficient of determination in calibration***

  $R^2_{cal} = 0.937$
- ***Coefficient of determination in prediction***

  $R^2_{pre} = 0.897$



Development of Calibrations for proximate & starch content in dried cassava flour

- Proximate & starch content calibrations developed and validated
- A total of 260 Spectra readings used
- 260 reference lab values generated were used
- Preliminary results:

Trait	R^2	
	Calibrated	**Prediction**
Moisture Content	0.86	0.89
Ash	0.93	0.94
Protein	0.91	0.94
Starch	0.62	0.57

Development of Calibrations for functional characteristics of Gari

- A calibration model for both both milled and un-milled Gari has been developed and validated.
- A total of 397 Spectra readings were used
- 397 reference lab values generated were used
- Preliminary results:

Trait	Un-milled Gari (R^2)		trait	Milled Gari (R^2)	
	Calibrated	Prediction		Calibrated	Prediction
Water Absorption Capacity (WAC)	0.42	0.53	Sugar	0.84	0.67
Dispersibility	0.65	0.53	Swelling Power	0.63	0.54
			Solubility	0.80	0.60

Development of SOPs for colour measurement

- Protocols for colour measurement for fresh root samples have been developed using a chromameter
- Developed SOPs for transfer of spectra data from Handheld Spectrophotometer to the benchtop XDS
- Calibrations + references and SOPs have all being uploaded on the RTBfoods platform

Capacity building – WP3

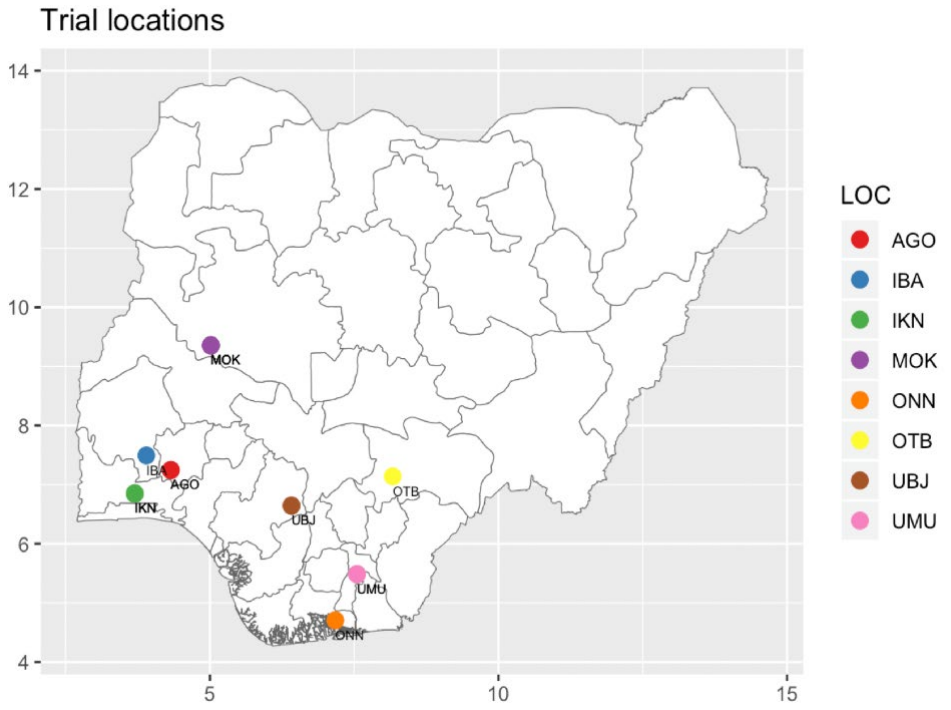
- A two-week NIRS training workshop conducted with supports from the WP3 leaders, PMU and NEXTGEN project

WP4: End-user focused breeding

Key Progress in Cassava Breeding for Quality

Promising cassava populations identified

Trial Name	Locations	No of Genotypes	Traits
GS Cycle 1 (NCRP)	Ikenne, Mokwa & Ibadan	18	DMC, Garri, DYLD, Garri weight, L, A, B
GS cycle 2 (UYT36 SetA)	Ikenne, Mokwa & Ibadan	36	DMC, Garri, DYLD, Garri weight, L, A, B
GS cycle 2 (UYT36 SetB)	Ikenne, Mokwa & Ibadan	36	DMC, Garri, DYLD, Garri weight, L, A, B



Additional Promising populations

Trial	IKN	AGO	IBD	ONNE	MOK	KANO	OTB	UBJ	UMK	ABJ	ZAR	Total
18NCRP	**54**	**54**			**54**			**54**		**54**	**54**	**324**
18.GS.C2.setA.UYT36	**108**	**108**	**108**	**108**	**108**	**108**	**108**		**108**			**864**
18.GS.C2.setb.UYT36	**108**	**108**	**108**	**108**	**108**	**108**	**108**		**108**			**864**
18.GS.C3.AYT28		84										84
18.GS.C3.AYT30	90				90			90				270
18.GS.C3B.AYT35	90			90								180
18.GS.C3B.AYT40			120									120
18.GS.C3.PYT24					48							48
18.GS.C3.PYT60		120										120
18.GS.C3B.PYT45			90									90
18.GS.C4.PYT50	100			100								200
18.GS.C4.PYT54	108		108	108								324
18.GS.C4.PYT80.SETA	160	160										320
18.GS.C4.PYT80.SETB	160	160										320
18.GS.C4B.CET250	250											250
18.GS.C4B.CET435	435											435
18.GS.C4B.CET560	560											560
18.GS.C4B.CET600.setA	600											600
18.GS.C4B.CET600.setB	600											600
18.Hawaii.CET.862	862											862
Total	4363	794	534	514	486	216	216	222	216	54	54	7669

Going beyond field phenotyping

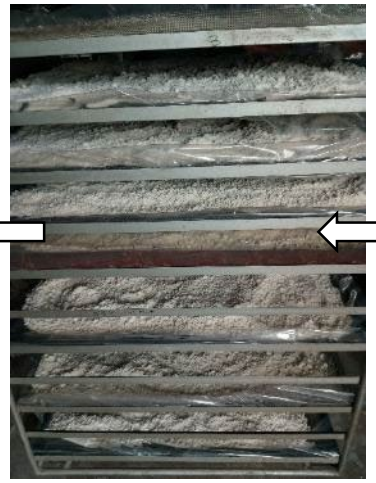
20 kg roots per plot

peeling, washing & retting (2-3 d)

Sieving mash to separate fiber from fufu

Decanting excess water

Assessment of fiber content



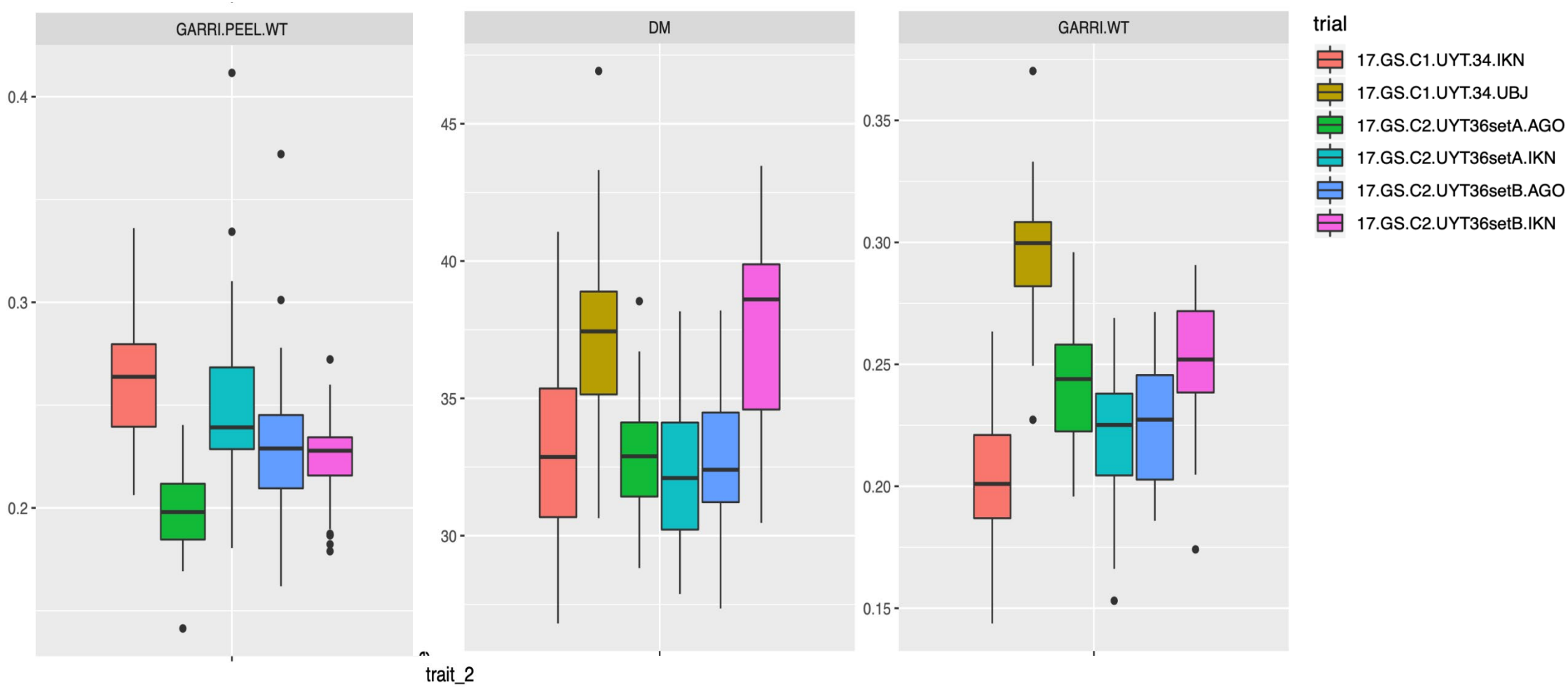
Drying at 80 C 48 h

Fufu weighed and stored

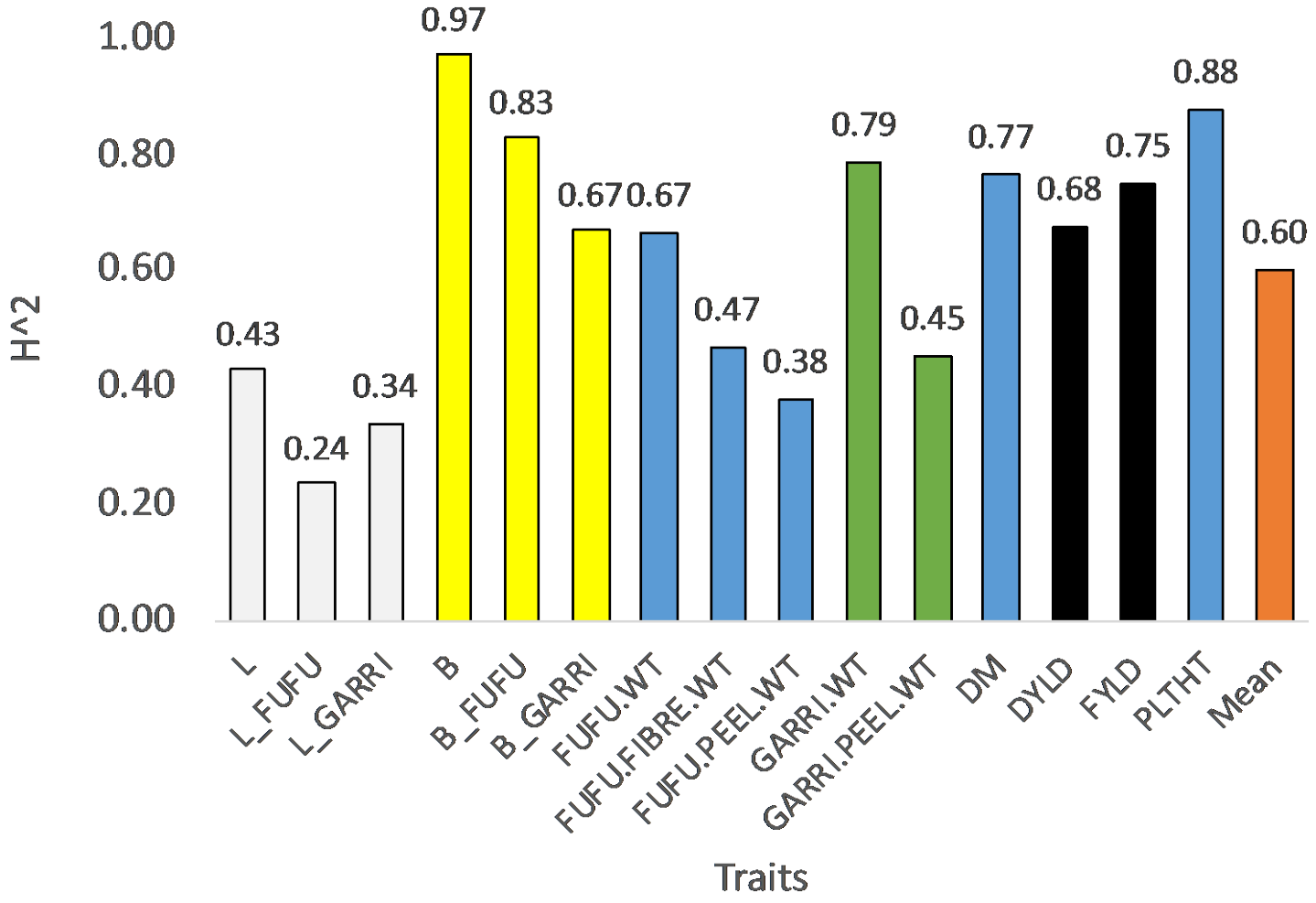
- > 800 samples of garri and fufu
- Foundation for RTBFoods WP2 and 3

Key Progress in Cassava Breeding for Quality

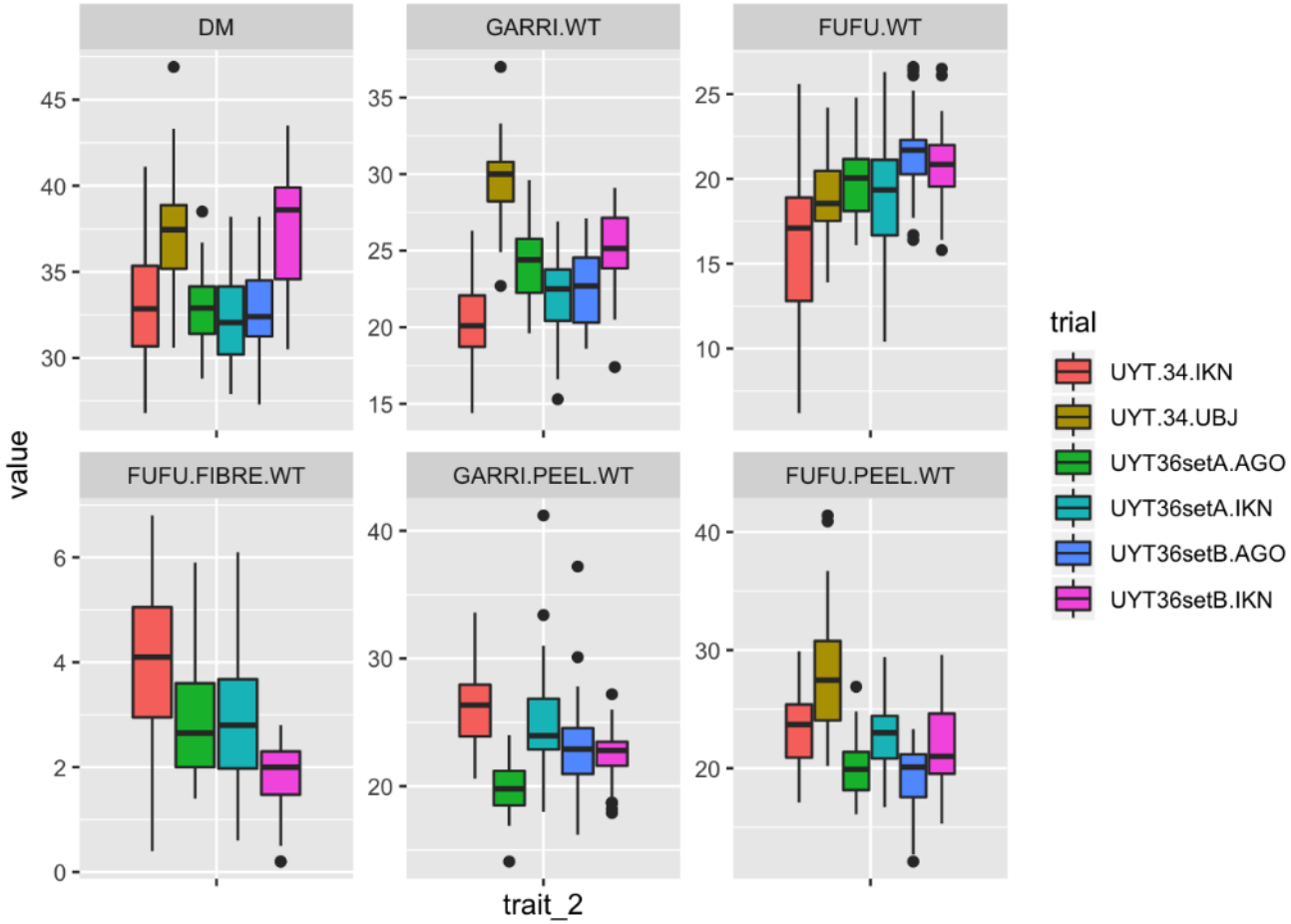
Multilocation studies for Garri and DM



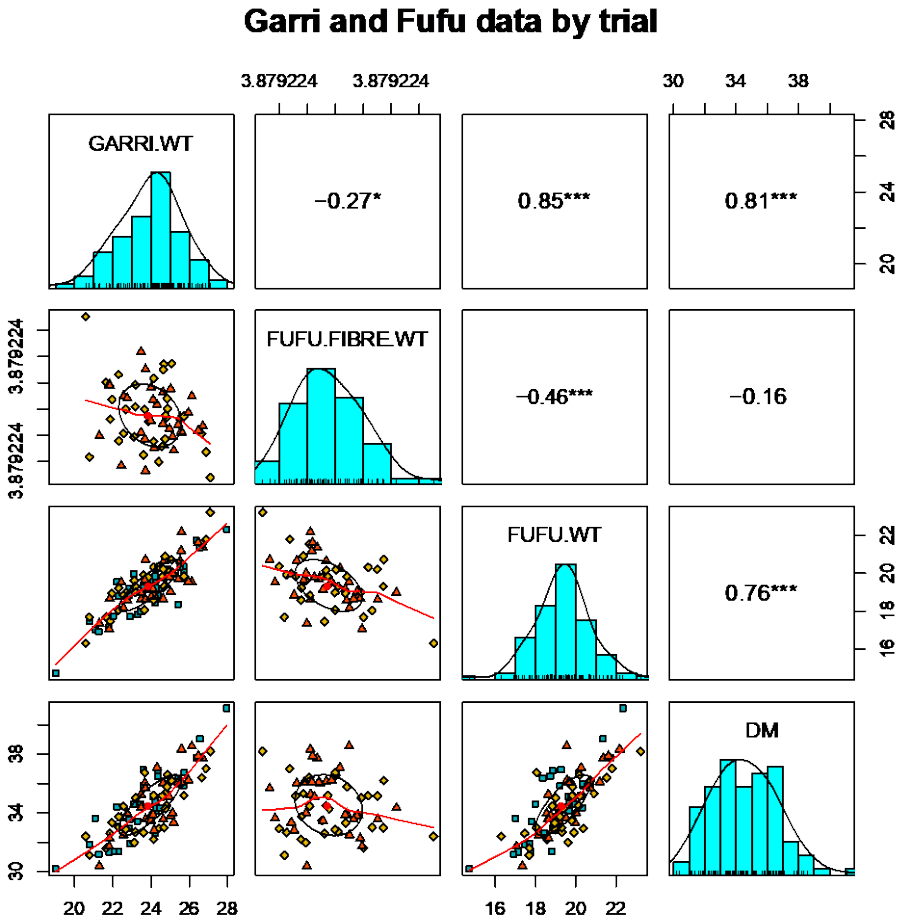
Trait Heritability Analysis



Garri, fufu, dry matter variation in UYT trials



Summary statistics for garri and fufu from UYT trials 20 KG fresh weight processed



Relationship between garri and fufu from UYT trials 20 KG fresh weight processed

Sharing of advanced breeding lines

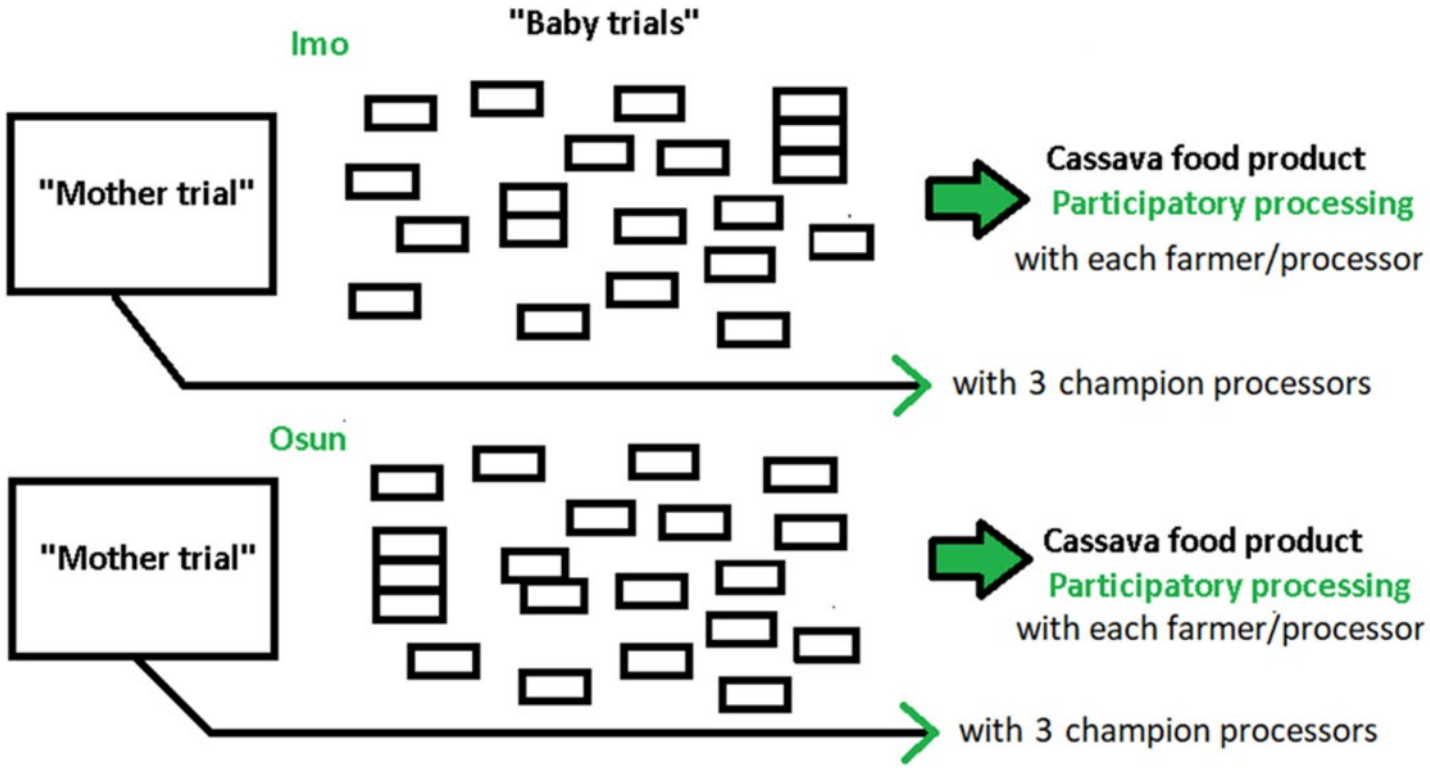
Advanced Breeding trial	Locations	No of Genotypes	Workpackage
Cycle1 (NCRP)	Ikenne, Mokwa & Ibadan	18	WP2 and WP3
UYT36 SetA	Ikenne, Mokwa & Ibadan	36	WP2 and WP3
UYT36 SetB	Ikenne, Mokwa & Ibadan	36	WP2 and WP3
On-farm varieties and landraces	Osun and Imo states	29	WP1, WP2 &WP5

WP5

Product profile mother baby trial approach – 2 years' data

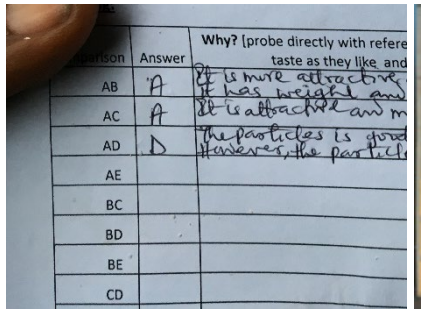
Evaluation of 20 varieties in Osun and Imo state: A mix of commonly cultivated, established improved and new Nextgen varieties

=> Contrast to elicit important user characteristics/traits



Gari Eba Fufu

Pairwise rank of varieties



Results

- Results show that a mix of commonly grown varieties (CMS study), established IITA improved clones and Nextgen clones are preferred for gari and eba quality. After food storage evaluation => landraces seem better
- The consistent presence of landraces TMB1, TMB2 and TMB 7 (Oko Iyawo) in the Gari and Eba indicates necessity to further evaluate what makes these varieties so good.
- Just like in the cassava breeding Demand Creation Trials (evaluated in 8 locations), Nextgen variety TMS13F1160P0004 was among the best for yield, dry matter and food product quality. TMS13F1176P0002 however had a clear discoloration and texture issue

Varieties evaluated in mother and baby trials:

1. TMEB419
2. TMS30572
3. K195
4. TMEB1
5. TMEB2
6. TMEB7
7. NR8082
8. TMEB693
9. TMS-IBA010040
10. TMS-IBA980581
11. TMS-IBA961632
12. TMS-IBA980505
13. TMS13F1365P0002
14. TMS13F1160P0004
15. TMS13F1176P0002

+5 to 9 local checks

Green=Nextgen
Black= Improved 'classic' IITA
Blue= Commonly grown by farmers

Varieties that are statistically better performing than the rest

		Osun state		Imo state	
	Overall	*Baby trials*	*Mother trials*	*Baby trials*	*Mother trials*
Yield	TMS-IBA980505	TMS-IBA980505	TMS-IBA980505	TMS13F1365P0002	TMS-IBA980581
	TMS13F1365P0002	TMEB1	TMS-IBA980581	TMS-IBA980505	
	TMS-IBA010040	TMS13F1365P0002	TMS-IBA961632	TMEB7	
	TMS-IBA961632	TMS-IBA010040	TMEB419	TMS-IBA961632	
	TMEB1	TMS-IBA980581	K195	K195	
		TMEB419	NR8082		
Density/DM	TMS13F1160P0004	TMEB419	TMEB419	TMS13F1160P0004	TMEB419
	TMEB419	TMS13F1176P0002	TMS13F1160P0004	TMS13F1176P0002	TMS13F1176P0002
	TMS13F1176P0002		TMS13F1176P0002	TMEB419	TMS13F1160P0004
	TMS-IBA961632		TMS30572	TMEB1	TMS13F1365P0002
			TMS13F1365P0002	TMEB2	TMS-IBA980505
					Chigazu
					Mgboto Umuahia
					Nwocha
					TMS-IBA961632
Fresh roots evaluation		TMS13F1365P0002	TMS13F1160P0004	TMS13F1176P0002	TMS13F1176P0002
		TMS-IBA980581	TMS13F1365P0002		TMEB2
		TMEB419	TMS-IBA961632		Agric
		TMS-IBA961632	K195		TMEB419
		TMEB7	TMS30572		
***Gari* evaluation**		TMS13F1160P0004	TMEB2	No sign. difference	TMS13F1365P0002
			TMS-IBA961632		Agric
			TMEB693		TMEB7
			TMS-IBA980581		TMS-IBA010040
			TMEB419		TMS-IBA980581
			TMS13F1365P0002		Chigazu
			LC(Atu/Honerable 2)		Nwageri
					Mgboto Umuahia
					TMEB1
					Salome (6 months)
***Eba* evaluation**		TMS13F1160P0004	TMS-IBA961632	no assesment	Agric
		TMS30572	TMS13F1160P0004		TMEB1
		TMEB1	TMEB7		TMS-IBA961632
		TMEB693	TMS-IBA980581		TMEB2
		TMS-IBA961632	LC(Atu/Honerable 2)		

Storage evaluation (2days) of Eba product by champion processors

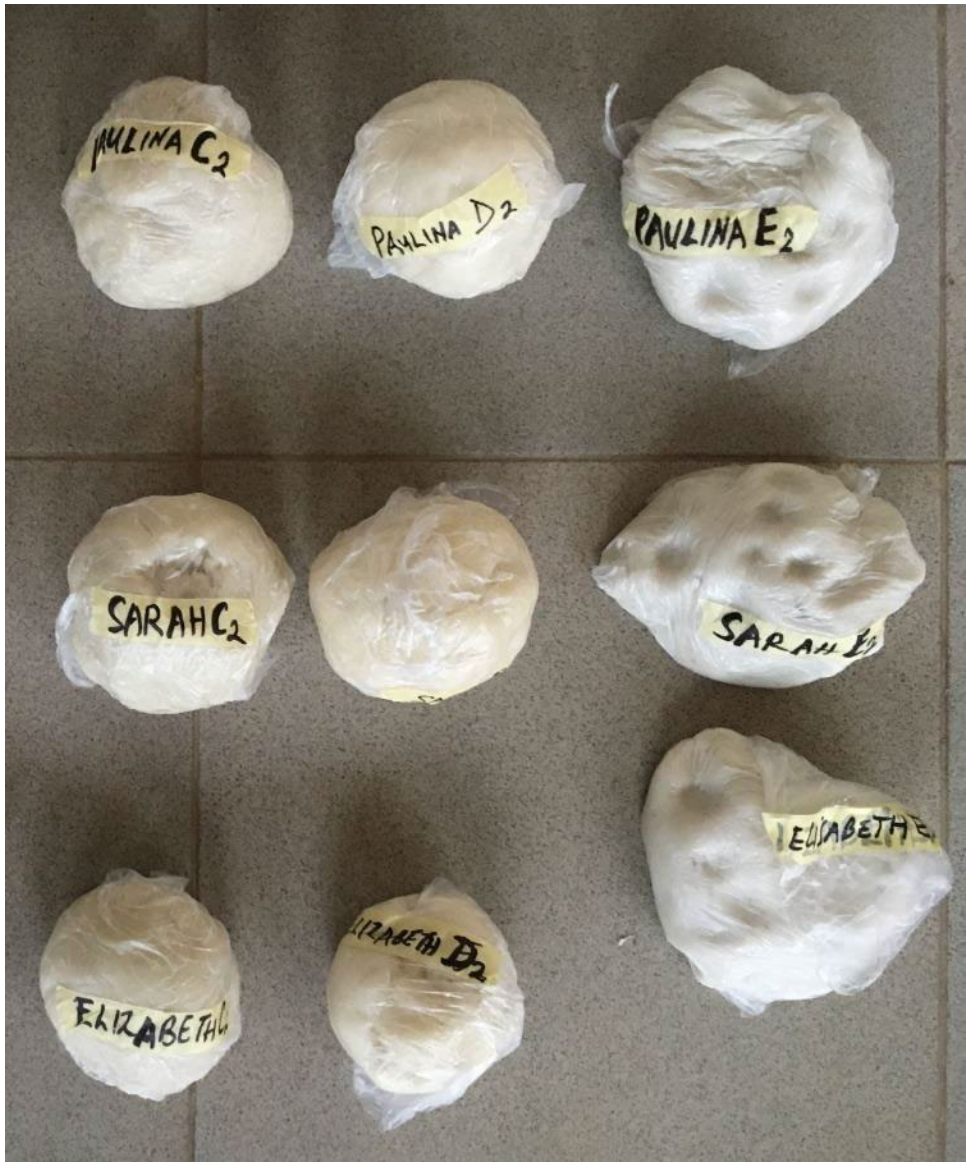
Batch	Best		Worst	
	2018	2019	2018	2019
1	TMS13F1160P0004	TMS-IBA961632	TMS13F1176P0002	TMS13F1160P0004
2	AKPU	NR8082	K195	TMS-IBA980505
3	TMEB693	AKPU	TMS-IITA-IBA30572	TMS13F1176P0002
4	Hon2	K195	TMS-IITA-IBA010040	TMEB419

Green=Nextgen
Black= Improved 'classic' IITA
Blue= Commonly grown by farmers

TMS13F1176P0002

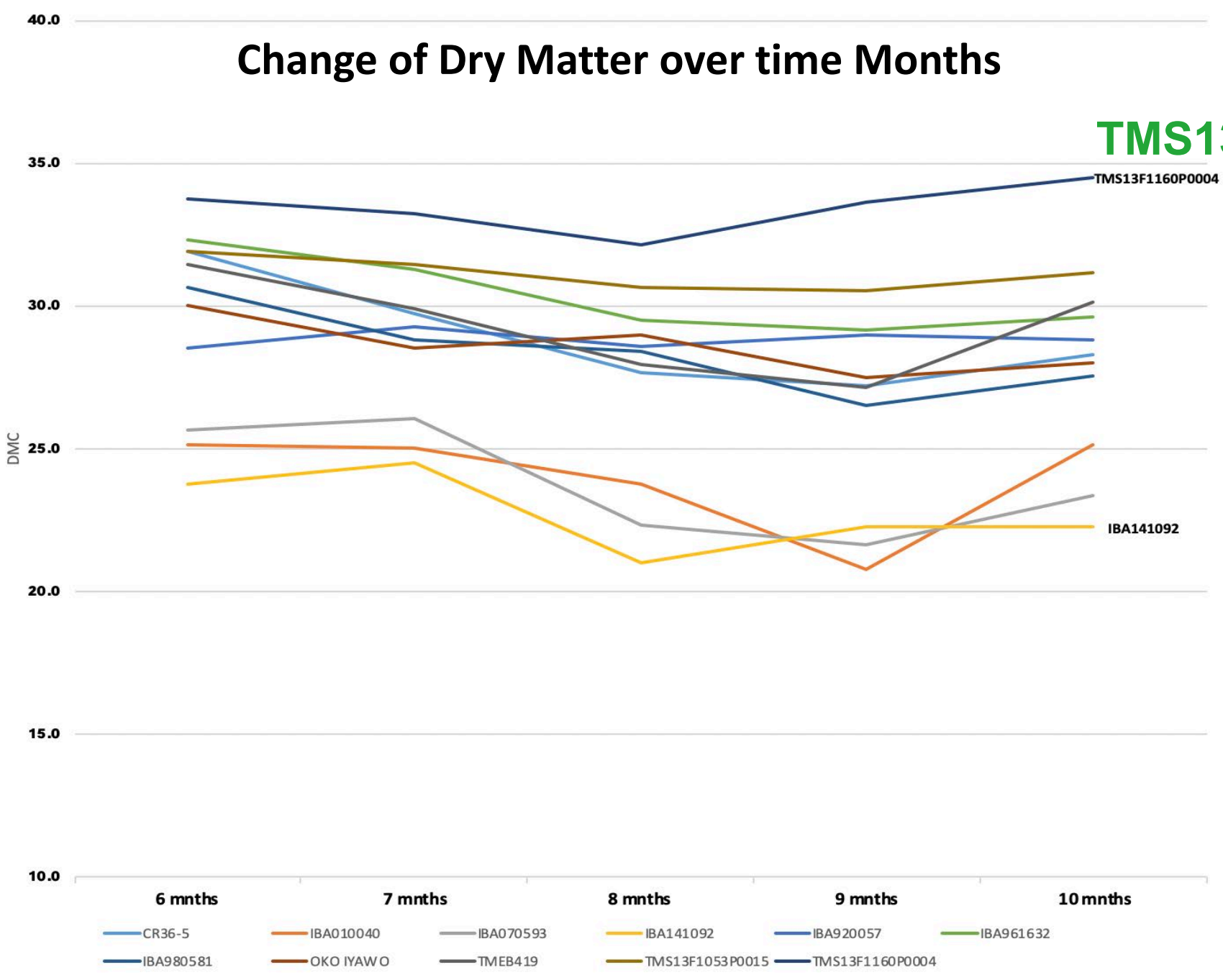
Eba

Fufu



Sieved out chaff from pressed pulp

Change of Dry Matter over time Months



TMS13F1160P0004

Important preferred characteristics elicited from the participatory processing

Fresh roots:

- Heavy root (high density)
- White root (often meaning also less water, watery roots make the root less chalky white)
- Big plumb roots (not long and slim)
- Less water ('ease of peel' is related to this: roots with less water are more difficult to peel but give more and better gari)
- As little as possible woody filaments in the root apart from the central core filament

Processing

- No discoloration during grating and fermentation of the pulp
- Pressed out water needs to be white, not off white
- Heavy, dense roots are less easy to grate in machine but give more and better quality gari
- Less chaff when sieving the fermented pulp (less woody filaments in the pulp, this is crucial especially there where fermented pulp is not re-grated, which in village settings is often the case)
- Well dewatered pulp. Some varieties dewater faster then others when pressed

Important preferred characteristics elicited from the participatory processing (continued)

Gari

- Bright shining color (be it white or butter colour)
- Heavy in hand (high density gari)
- Even granule size, not too large not to powderish (for drinking larger granule size is often preferred)
- Less woody filaments in the gari
- Good taste not bland/flat but full with aroma (not only a degree of sourness)

Eba:

- Good swelling of the gari when making eba (related to the heaviness, 'density' of gari)
- Bright (be it white or butter colored) attractive neat looking colour (not grey or brown!)
- Smooth eba, particles of gari nicely merged
- Does not stick to the hand and is mouldable and soft
- Good taste

Fufu

- Bright (be it of white or off white) colour, not too chalky white (means it is not well cooked)
- Should not stick to the hand and be mouldable and soft
- Good cohesiveness (not sag out when stored -> important users often store for some days)

Conclusions for WP1 to WP5

Breeding is addressing important characteristics such as **dry matter** and **starch.**

Results from WP 1 and WP 5 indicate that the following aspects need attention:

- Brightness/colour and discoloration during processing,
- Eba holding its shape and desired softness and drawability (cohesiveness, that it does not sack out, not sticky to hands), storing food product for some time seems to bring out differences well.
- Dry matter stability to assure good ‘heavy’ roots whole year round
- Easy water release during processing (which might only be partially related to dry matter content)
- Woody filament (crude fiber) related aspects

Physiochemical properties related to these issues should be investigated by WP 2 by developing diagnostic protocols so WP3 can develop high throughput phenotyping methods to inform breeders (WP4)

Potential proof of concepts to be developed

Discoloration during processing: loss off bright coloured/white gari and eba:

- Hypothesis:

  caused by Polyphenols that oxidate: before cooking

  caused by Chorogenitic acid: after cooking gari into eba

  If true=> develop prediction through NIRS

Lose of firmness/texture

- Hypothesis 1:

  Caused by methylation of pectin influences gelling properties of dough

- Hypothesis 2:

  Caused by starch structure (type of starch e.g. quantity of resistant starch

Evaluation after storage can help in clearer diagnostics and proof of concept development

Potential proof of concepts to be developed

- Stability of dry matter
- Canopy cover (weed competitiveness)?
- IJFST issue. Discussion on cooperation with Gari Cameroon and Atieke Ivory Coast ongoing: separate articles or combined depending the datasets.

RTB foods

BILL & MELINDA GATES foundation

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NEXTGEN CASSAVA

BTI BOYCE THOMPSON INSTITUTE

CGIAR RESEARCH PROGRAM ON Roots, Tubers and Bananas