AfricaYam Meeting, Nigeria 17/09/2022

Discriminant textural methods for pounded yam and boiled yam in relation to sensory and consumer preferences

Speaker: Oluwatoyin AYETIGBO

Food Scientist in Physical Measurements & Focal Point for RTBfoods Texture, CIRAD, France.

Discriminant textural methods for pounded yam and boiled yam in relation to sensory and consumer preferences

AfricaYam Meeting, Nigeria, 17/09/2022

Oluwatoyin AYETIGBO
CIRAD, Montpellier, France

Contributors
R. DOMINGO, CIRAD, Montpellier, France
S. ARUFE, CIRAD, Montpellier, France
C. MESTRES, CIRAD, Montpellier, France
D. DUFOUR, CIRAD, Montpellier, France

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Introduction

- Outline
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    - Penetration
    - Extrusion
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    - SOP 1: Uniaxial extensibility
    - SOP 2: Biaxial extensional viscosity
    - Correlations with sensory texture and consumer tests
  - Future in perspective…

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Introduction

- The RTBfoods Project focus on the linkages between heritable RTB crop traits and consumer preferences for RTB food product profiles.
- Pounded yam and boiled yam are the primary food product profiles produced from yams, especially of the ***rotundata*** and ***alata*** species. The *rotundata* species are particularly more preferred for pounded yam, while both species can be preferred for boiled yam.

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SOPs – Instrumental texture

- It is important to develop reproducible and discriminant instrumental texture protocols to measure the key sensory texture of boiled yam and pounded yam.
- The instrumental textural protocols used in RTBfoods are:
  - **Texture profile analysis (TPA)**
  - **Penetration**
  - **Extrusion**
  - **Uniaxial extensibility**
  - **Lubricated squeeze flow (LSF)/Biaxial extensional viscosity (BEV)**
- This will provides mid-throughput protocols to screen large populations of yams for selection of yam genotypes for advanced breeding toward consumer adoption and acceptance.

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Product profiles and key sensory attributes

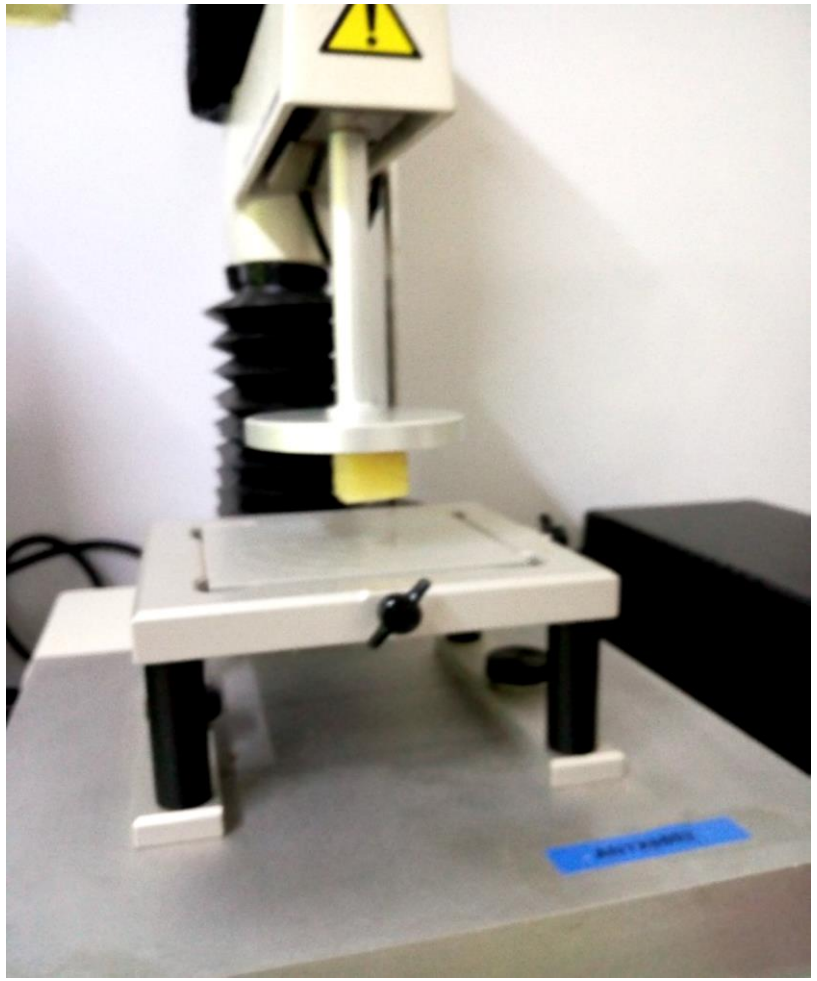
RTBfoods partner	Product profile	Country	Key sensory attributes
BOWEN University, Iwo	Pounded yam	Nigeria	Stretchability, Mouldability, Smoothness, Stickiness, Hardness
NRCRI, Umudike	Pounded yam	Nigeria	Stretchability, Mouldability, Smoothness, Stickiness, Hardness
FSA-UAC, Cotonou	Boiled yam	Benin	Friability/Mealiness, Chewiness
NRCRI, Umudike	Boiled yam	Nigeria	Softness
IITA, Ibadan	Boiled yam	Nigeria	Hardness, Chewiness

Source: Scientific Progress Report RTBfoods WP2 Period 4, Biophysical Characterization of Quality Traits. https://doi.org/10.18167/agritrop/00688

Case studies on SOPs – Instrumental texture

Partner	Product profile	Key sensory attributes	Texture protocol	Key discriminant Instrumental attributes	Significant correlations between instrumental and sensory/consumer tests
BOWEN University	Pounded yam	Stretchability, Mouldability, Smoothness, Stickiness, Hardness	TPA	Gumminess, Hardness, Adhesiveness	Chewiness, Gumminess, Cohesiveness versus Moldability & Stretchability
FSA-UAC	Boiled yam	Friability, Chewiness	TPA & Penetrometry	Hardness, adhesiveness, chewiness, cohesiveness	Firmness (hard to break) & hardness & Area (work done to penetrate)
CIRAD & FSA-UAC	Pounded yam	Stretchability	Uniaxial Extension & LSF	Extensibility, Area under curve, BEV	Hardness & consumer likeability, Hardness & Stretchability Extensional viscosity & consumer likeability
IITA	Boiled yam	Hardness, Chewiness	Extrusion	Hardness, stickiness	NA

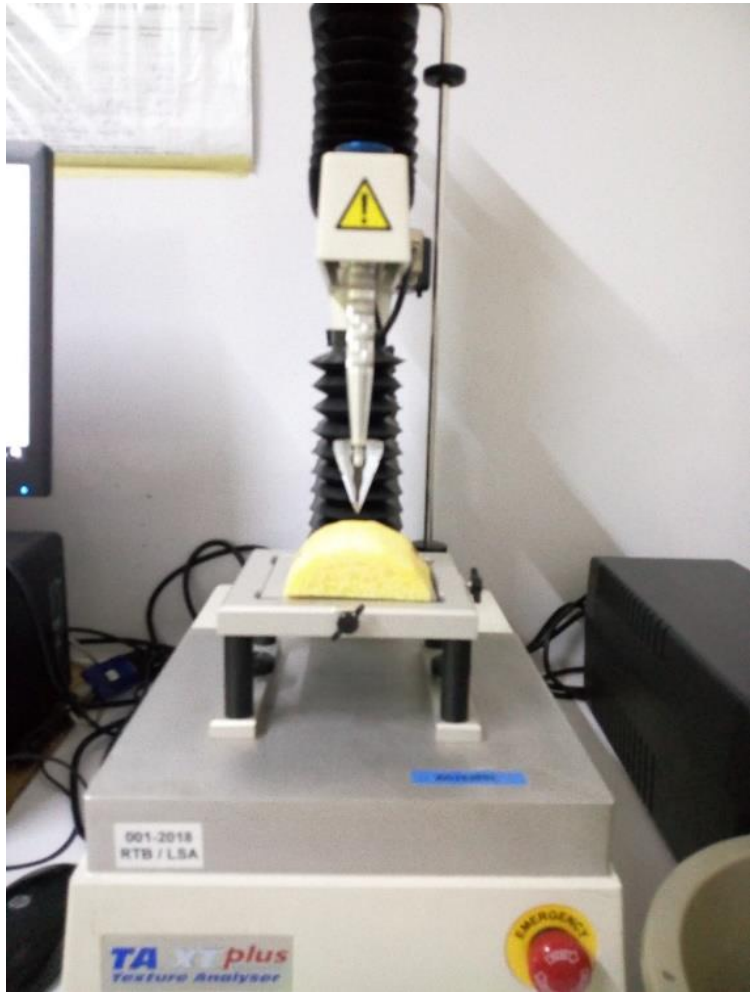
TPA – boiled yam - Benin



In Benin, for 15 genotypes of yam boiled into boiled yam product, TPA protocol is both repeatable and discriminant, and can provide more textural information than penetration protocol. The most discriminating TPA attributes are hardness, adhesiveness, chewiness & cohesiveness. TPA protocol is often less discriminant than penetration.

https://doi.org/10.18167/agritrop/00603

Penetration – boiled yam- Benin

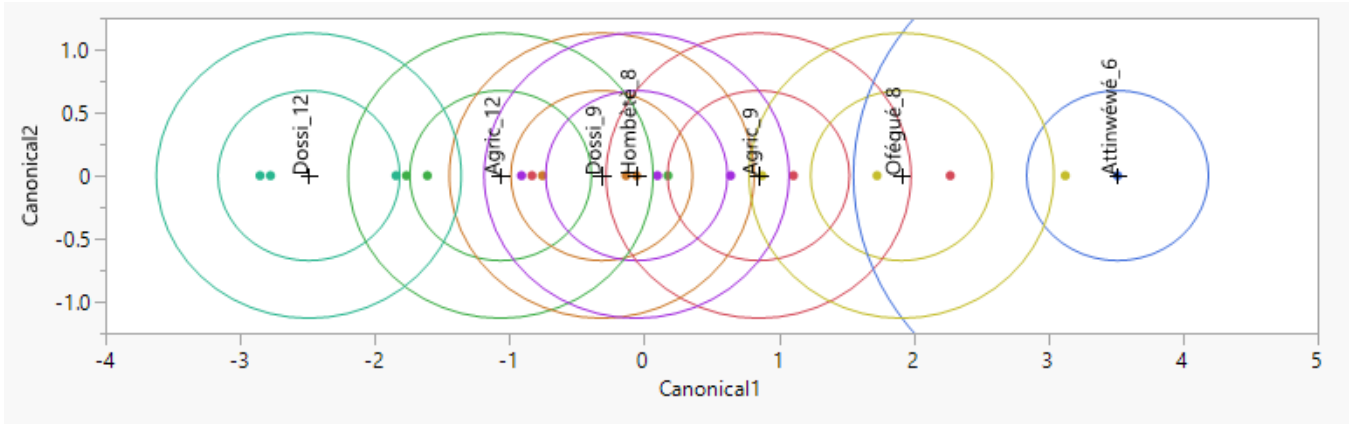


In Benin, for 15 genotypes of yam boiled into boiled yam product, penetration was both a repeatable and discriminating protocol. Hardness was the more discriminant attribute. There was significant correlation between sensory 'hard to break' & penetration hardness & work done to penetrate. Penetration method was less repeatable than TPA, but more discriminant.

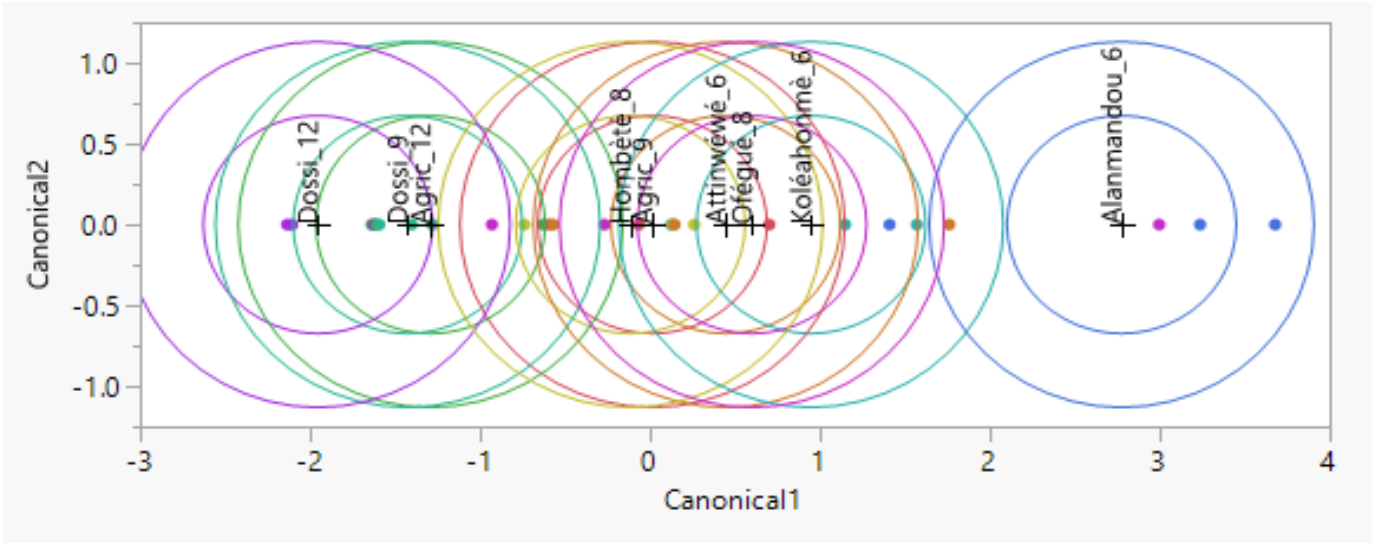
https://doi.org/10.18167/agritrop/00603

TPA, Penetration, Extrusion – boiled yam- Benin

- Considering hardness as examplary key attribute



Penetration

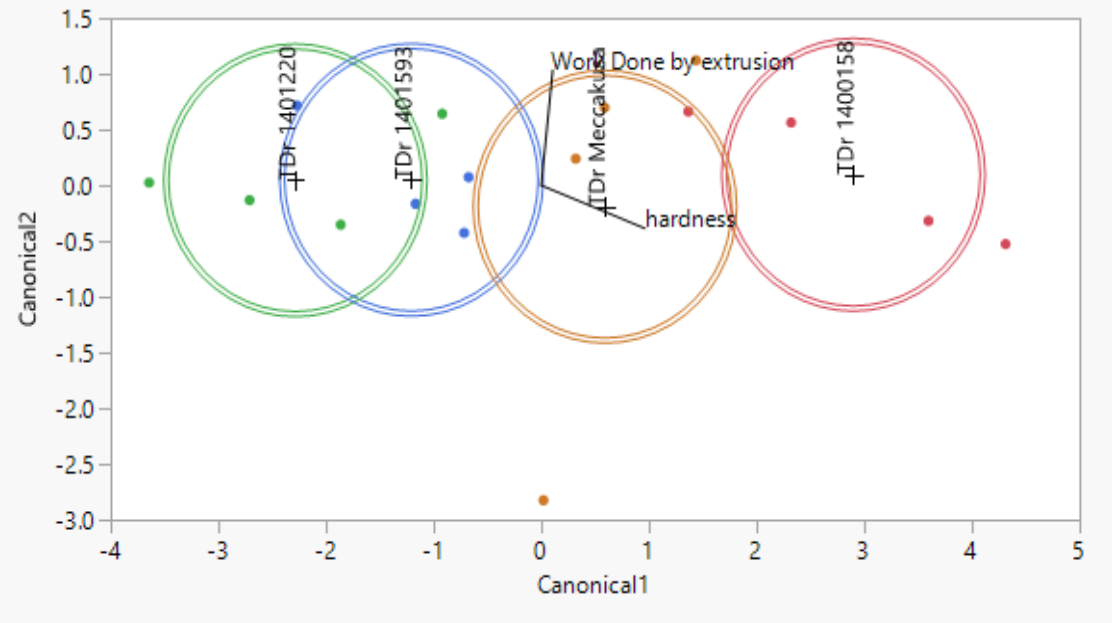


TPA

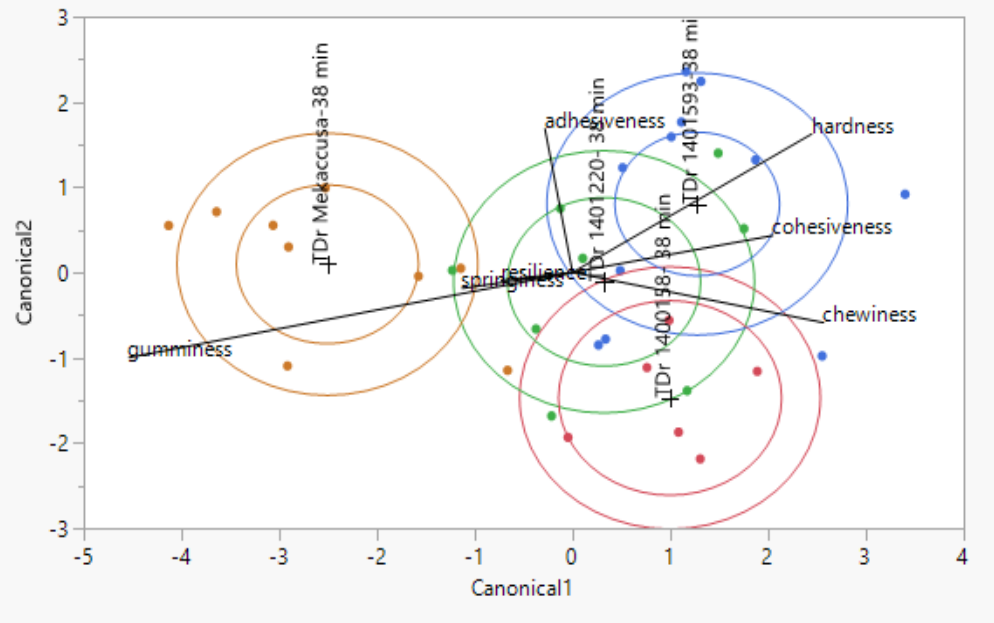
Extrusion – boiled yam –IITA

Using extrusion protocol for boiled yam texture characterization of 16 yam genotypes at IITA, Nigeria, it was found that extrusion protocol was more repeatable and discriminant compared to TPA. The extrusion hardness was more discriminant attribute than work done by extrusion (area under the curve).

Extrusion – boiled yam -IITA



Extrusion



TPA

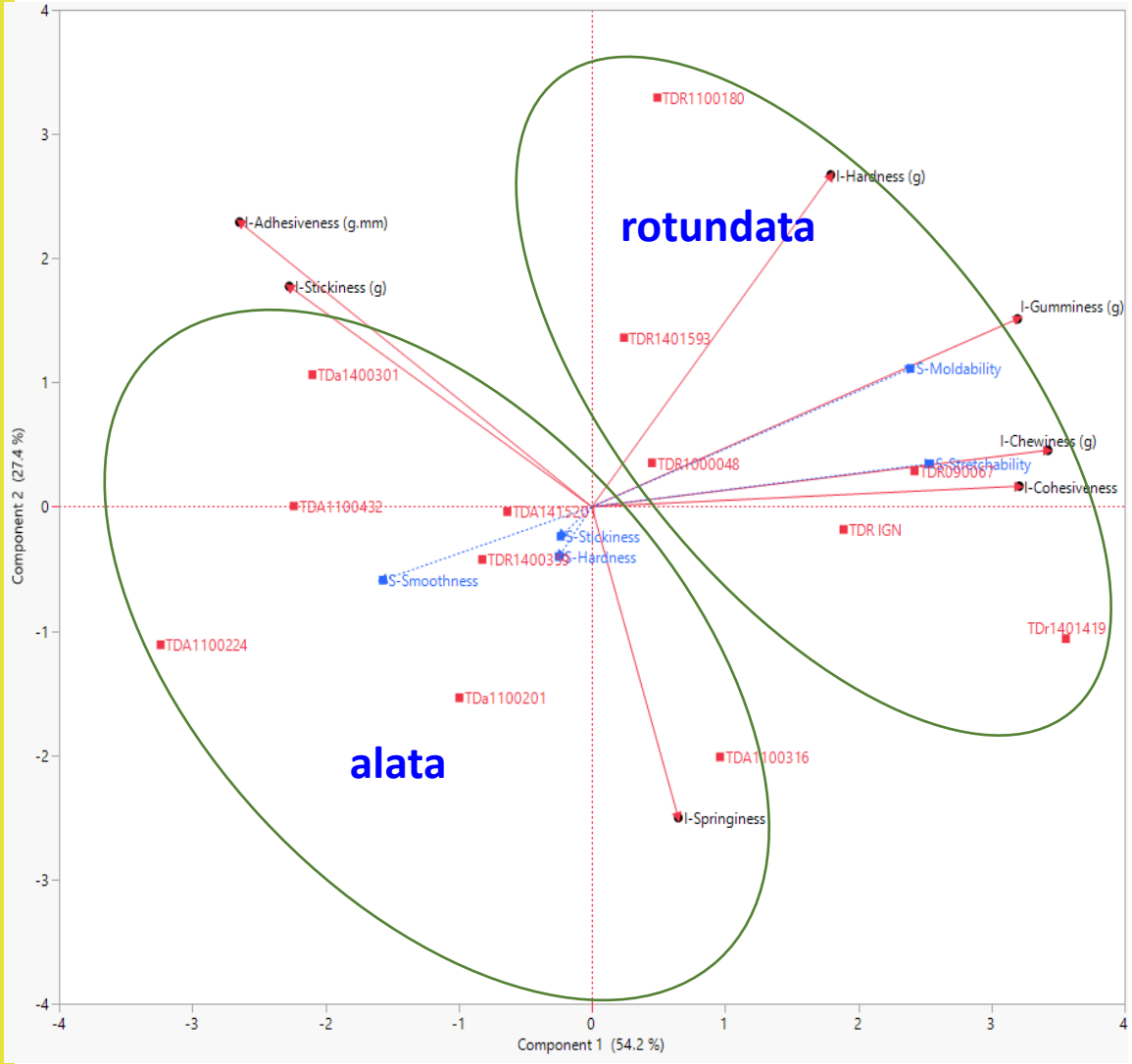
- An SOP is currently being written in IITA.

TPA – pounded yam – Bowen, Nigeria

- Texture analyzer

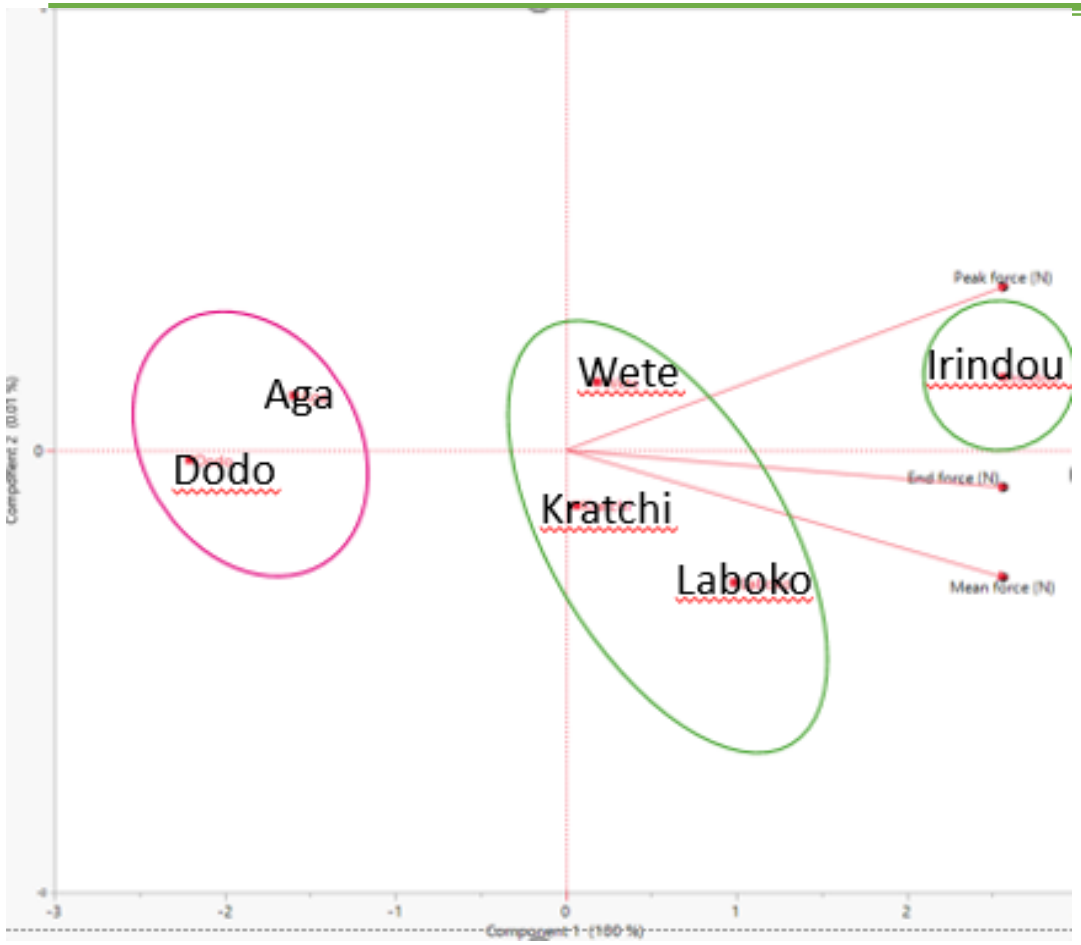
https://doi.org/10.18167/agritrop/00613

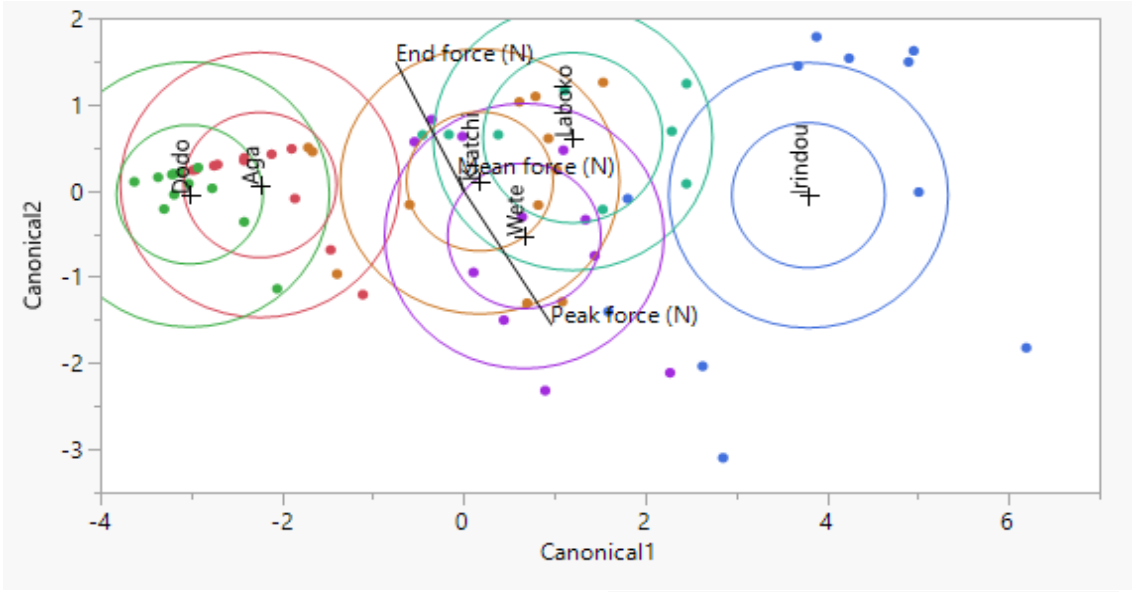
TPA – pounded yam – Bowen, Nigeria



- In BOWEN, TPA protocol was repeatable and discriminant especially between pounded yam texture for *alata* and *rotundata* yams.
- PCA grouped *alata* species separate from *rotundata* species with *alata* more associated with adhesiveness and stickiness, and *rotundata* are more associated with cohesiveness, chewiness, gumminess, and hardness.
- Significant correlations were found between instrumental chewiness, gumminess, cohesiveness & sensory mouldability and stretchability.

Extrusion – Pounded yam – UAC-FSA, Benin





Connecting Letters Report

Level			Mean
Irindou	A		90.717333
Laboko		B	65.498417
Wete		B	54.238250
Kratchi		B	51.780750
Aga		C	26.626750
Dodo		C	17.056333

- In UAC-FSA, Benin, Extrusion protocol was repeatable and discriminant, especially between pounded yam texture for *alata* and *rotundata* yams.

Comparison of textural protocols for Yam FPPs

- Overall, repeatability and discriminability varies for the protocols.
- Boiled FPP better analysed by extrusion and penetration protocols.
- Paste FPPs satisfactorily analysed by TPA & extrusion.

****Stretchability of pounded yam is variably correlated with these instrumental protocols in Benin & BOWEN.

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Development of new SOPs for texture of Pounded yam

- Stretchability is one of the key textural attributes preferred by consumers of pounded yam.
- Need to develop reproducible, discriminant instrumental texture protocols to measure the stretchability of pounded yam.
- The SOPs will provide mid-throughput protocols to screen large populations of yams for selection of yam genotypes for advanced breeding toward consumer adoption and preference for pounded yam.

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SOP- Extensibility - CIRAD

- Two standard operating protocols (SOP) have been developed to measure extensibility of pounded yam:

  - Uniaxial extensibility https://doi.org/10.18167/agritrop/00684
  - Biaxial extension by lubricated squeeze flow (LSF) https://doi.org/10.18167/agritrop/00686

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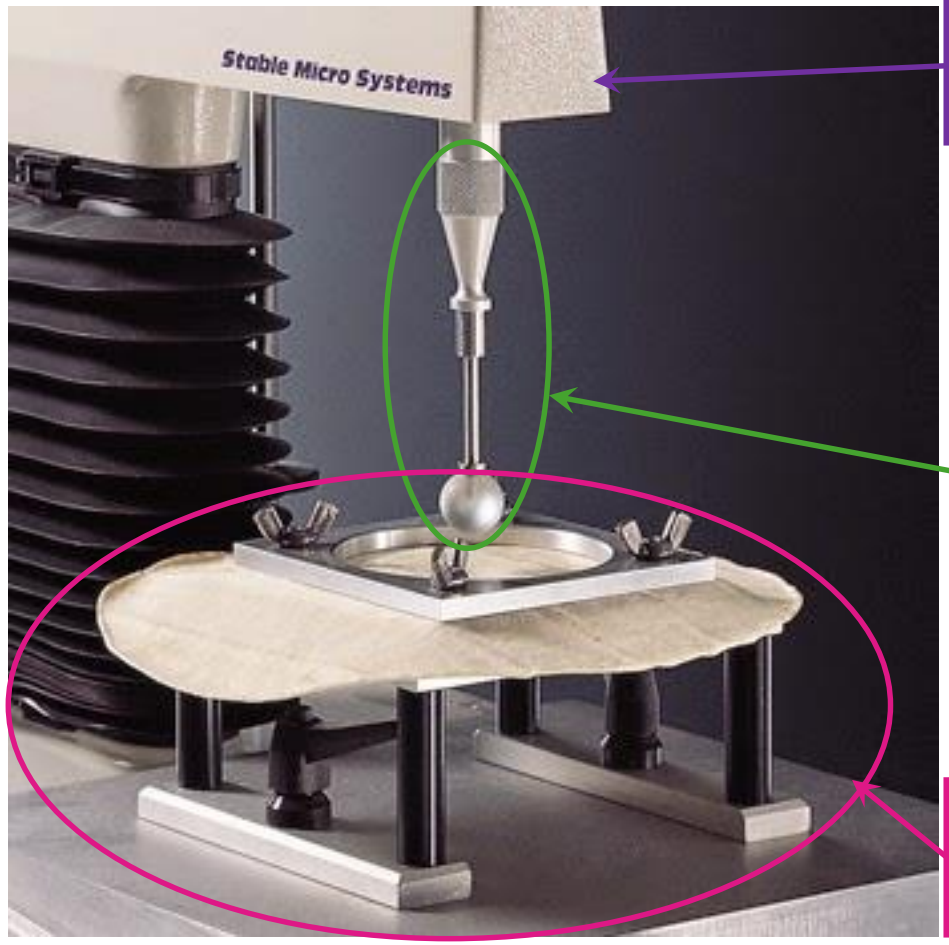
SOP 1: Uniaxial Extensibility

- **Materials**



Texture analyser (TA-XT Plus, Stable Micro Systems Ltd., Surrey, UK) with Exponent Software Interface

P/1SP standard ball probe

The tortilla/pastry burst rig (HDP/TPB)

SOP: Uniaxial Extensibility

- **Preparation of pounded yam dough sheet** (SOP, Otegbayo et al. 2022) https://doi.org/10.18167/agritrop/00613

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SOP: Uniaxial Extensibility

- **QDA and consumer tests**
  - 13 trained panelists
  - Scores ‘stretchability’ and ‘mouldability’ for 18 samples (6 varieties x 3 replicates), 0 – 10 cm semi-structured scale, following sensory SOP Otegbayo et al. (2021).
- **Consumer overall likeability** – (Honfozo et al. 2021)
  - 9-point hedonic scale (1 = “dislike extremely”, 9 = “like extremely”) two rural districts (*Dassa* and *Glazoué*) of Benin.
  - Participants (n = 99) were randomly selected, 18 - 70 years old, 48.5% males and 51.5% females

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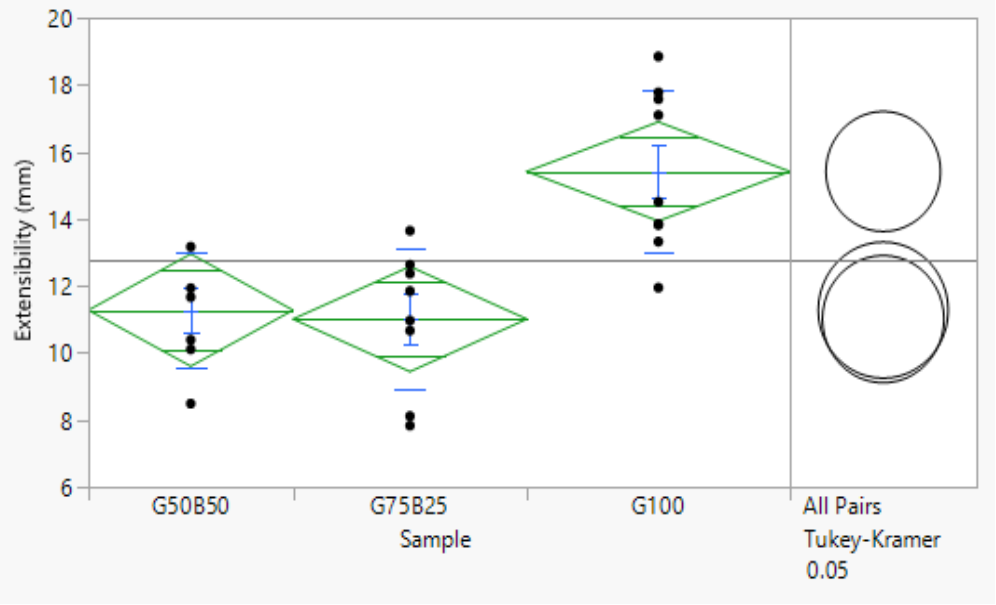
SOP: Uniaxial Extensibility

- **Critical points/ Limitations**
  - The method is difficult or impossible to use with food product profiles that fracture (brittle) easily or too adhesive, e.g. some *alata* species of yam, *eba*, *amala*.

SOP: Uniaxial Extensibility

- Results: accuracy, repeatability, discriminant



Repeatability

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
replicate	1	29.33102	29.3310	3.8061	0.0639
Error	22	169.53866	7.7063		
C. Total	23	198.86968			

Accuracy

Level	Number	Mean	Std Dev	Std Err Mean	CV (%)
G50B50	7	11.28	1.72	0.65	15
G75B25	8	11.01	2.09	0.74	19
G100	9	15.42	2.43	0.81	16

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Sample	2	103.35	51.67	11.36	0.0005*
Error	21	95.52	4.55		
C. Total	23	198.87			

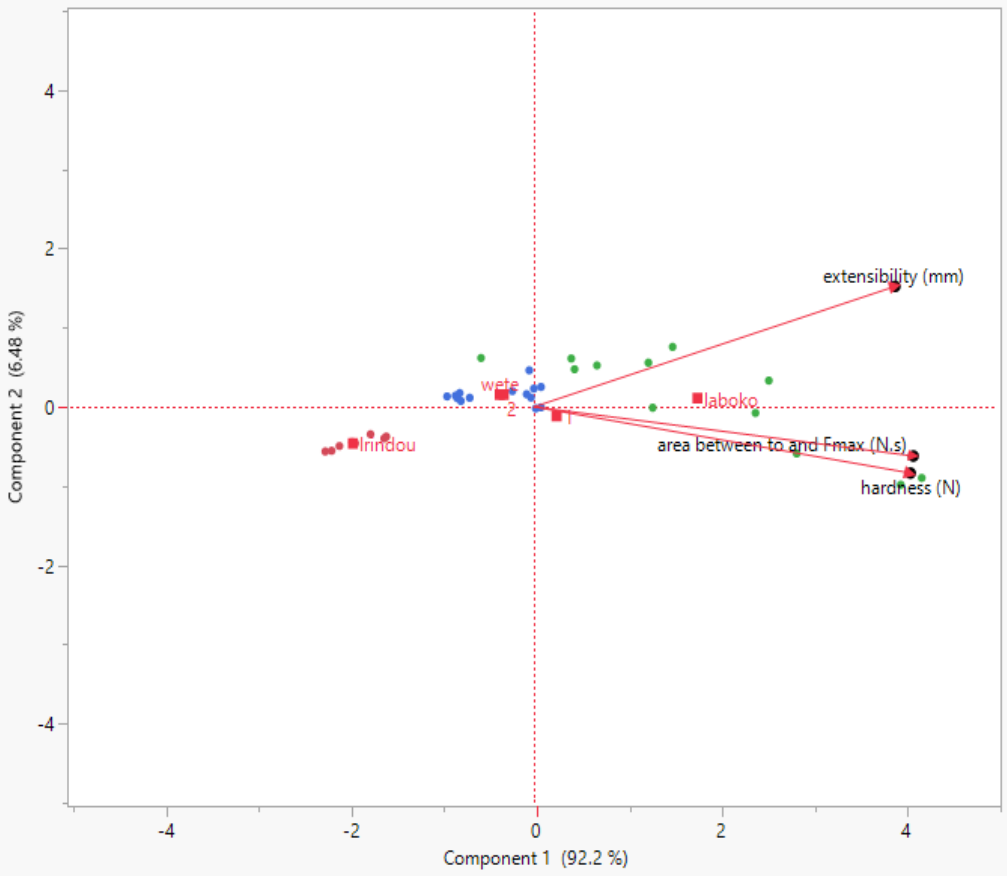
Connecting Letters Report

Level			Mean
G100	A		15.42
G50B50		B	11.28
G75B25		B	11.01

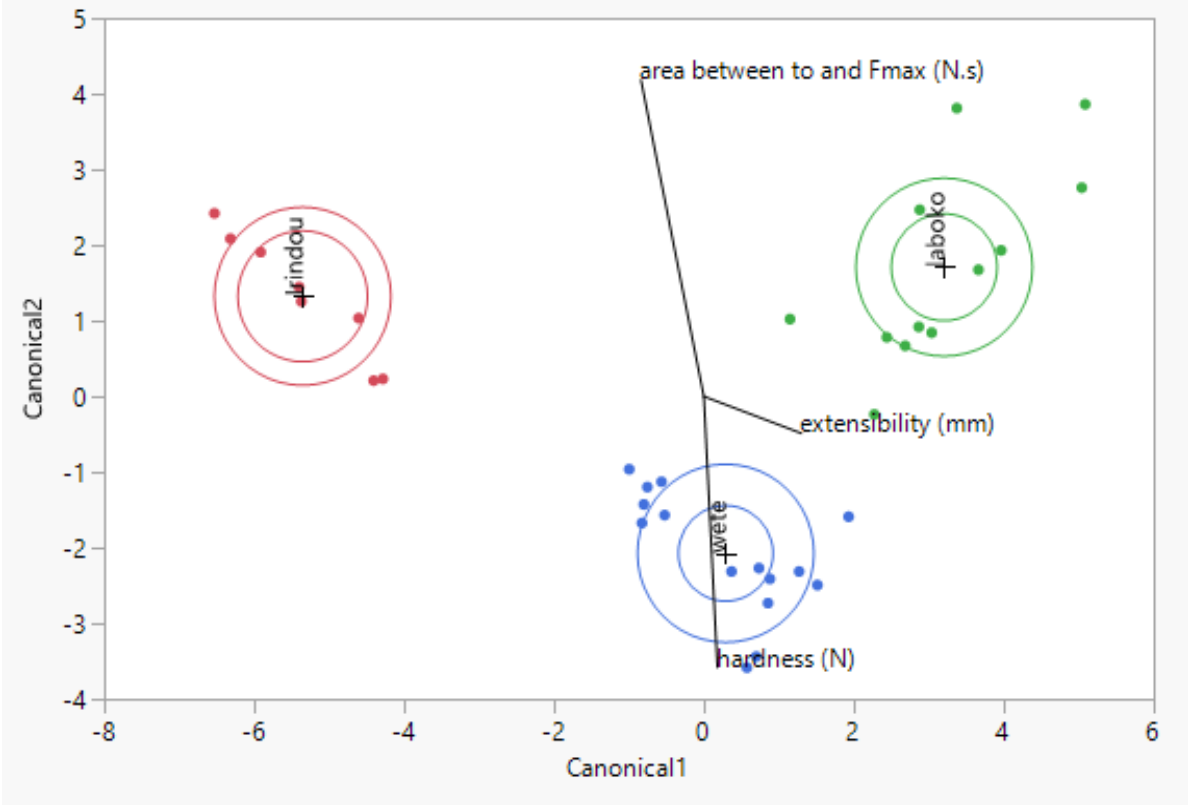
Levels not connected by same letter are significantly different.

SOP: Uniaxial Extensibility

- Validation of SOP: 4 contrasting yam variaties - *Aga* (*alata*) and *Wete* + *Irindou* + *Laboko* (*rotundata*) from Benin. *Aga* was too brittle to form dough sheet



PCA



Discriminant analysis

SOP: Uniaxial Extensibility

Parameter	Hardness (N)	Extensibility (mm)	area between t_o and F_{max} (N.s)	Stretchability	Mouldability	Consumer overall likeability
Extensibility (mm)	0.9928	1.0000				
Area between t_o and F_{max} (N.s)	0.9733	0.9387	1.0000			
Stretchability	0.9880	0.9622	0.9971	1.0000		
Mouldability	0.8700	0.9230	0.7337	0.7833	1.0000	
Consumer overall likeability	0.8791	0.8154	0.9650	0.9422	0.5298	1.0000
	Probability					
Extensibility (mm)	0.0767	<.0001				
Area between t_o and F_{max} (N.s)	0.1474	0.2240	<.0001			
Stretchability	0.0989	0.1756	0.0485	<.0001		
Mouldability	0.3282	0.2515	0.4756	0.4271	<.0001	
Consumer overall likeability	0.3163	0.3930	0.1689	0.2174	0.6445	<.0001

Significant correlations between Sensory stretchability and Instrumental work done for extension (N = 3 genotypes)

SOP: Uniaxial Extensibility

	hardness (N)	extensibility (mm)	area between to and F_{max} (N.mm)	stretchability	mouldability	overall consumer likeability
	Coefficients					
hardness (N)	1.0000					
extensibility (mm)	0.9638	1.0000				
area between to and Fmax (N.mm)	0.9407	0.9337	1.0000			
extensional viscosity (Pa.s)	0.9003	0.7951	0.9293			
stretchability	0.4822	0.6535	0.5513	1.0000		
mouldability	-0.2924	-0.0275	-0.1831	0.5714	1.0000	
overall consumer likeability	0.9272	0.8021	0.8762	0.2601	-0.5929	1.0000
	Probability					
hardness (N)	<.0001					
extensibility (mm)	0.0082	<.0001				
area between to and Fmax (N.mm)	0.0172	0.0203	<.0001			
stretchability	0.4108	0.2317	0.3355	<.0001		
mouldability	0.6331	0.9650	0.7682	0.3143	<.0001	
overall consumer likeability	0.0233	0.1025	0.0513	0.6726	0.2920	<.0001

Significant correlations between consumer likeability and Instrumental hardness, work done for extension, and extensional viscosity (N = 5 genotypes)

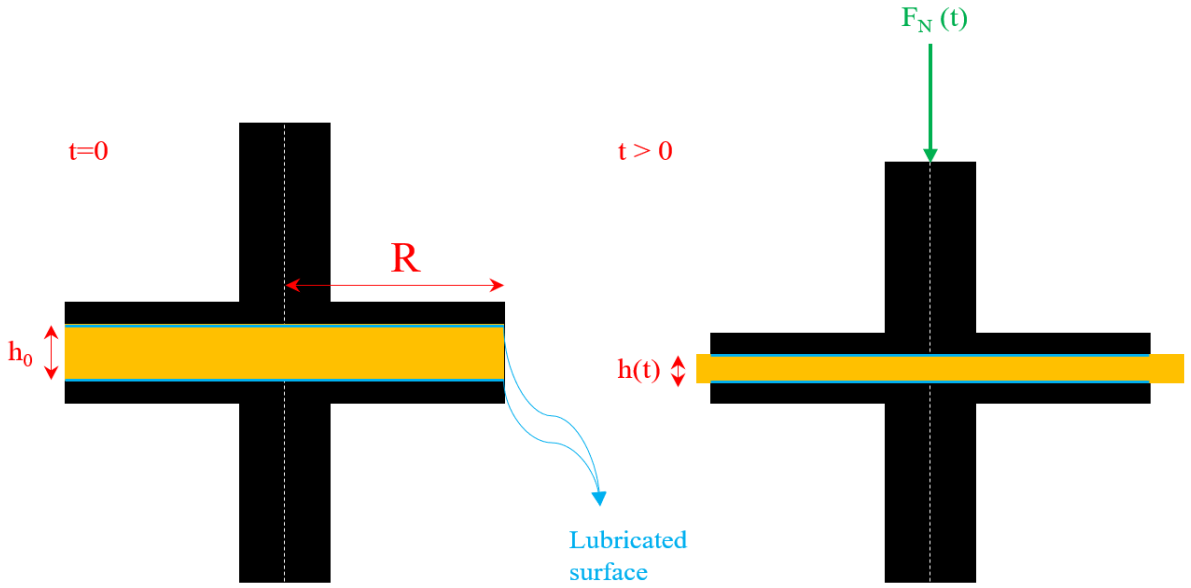
SOP: Uniaxial Extensibility

Thresholds for QDA and Instrumental attributes of pounded yam in Benin

		QDA (sensory) tests		Extensibility test	
Attributes	Threshold	% JAR - consumers	QDA	Extensibility (mm)	Area (N.mm)
Stretchability	Optimal	90	5.764 - 6.810	7.8 – 10.7	4.9 – 7.8
	Acceptable	70	4.665 - 5.764	4.8 – 7.8	1.9 – 4.9
			6.810 - 7.909	10.7 - 13.7	7.8 – 10.9
Softness	Optimal	80	5.656 - 6.632		
	Acceptable	60	4.930 -5.656		
			6.632 - 7.358		

SOP 2: Biaxial Extensional Viscosity

- Determination of biaxial extensional viscosity (BEV) of pounded yam measures the biaxial flow between two different plates by compression.



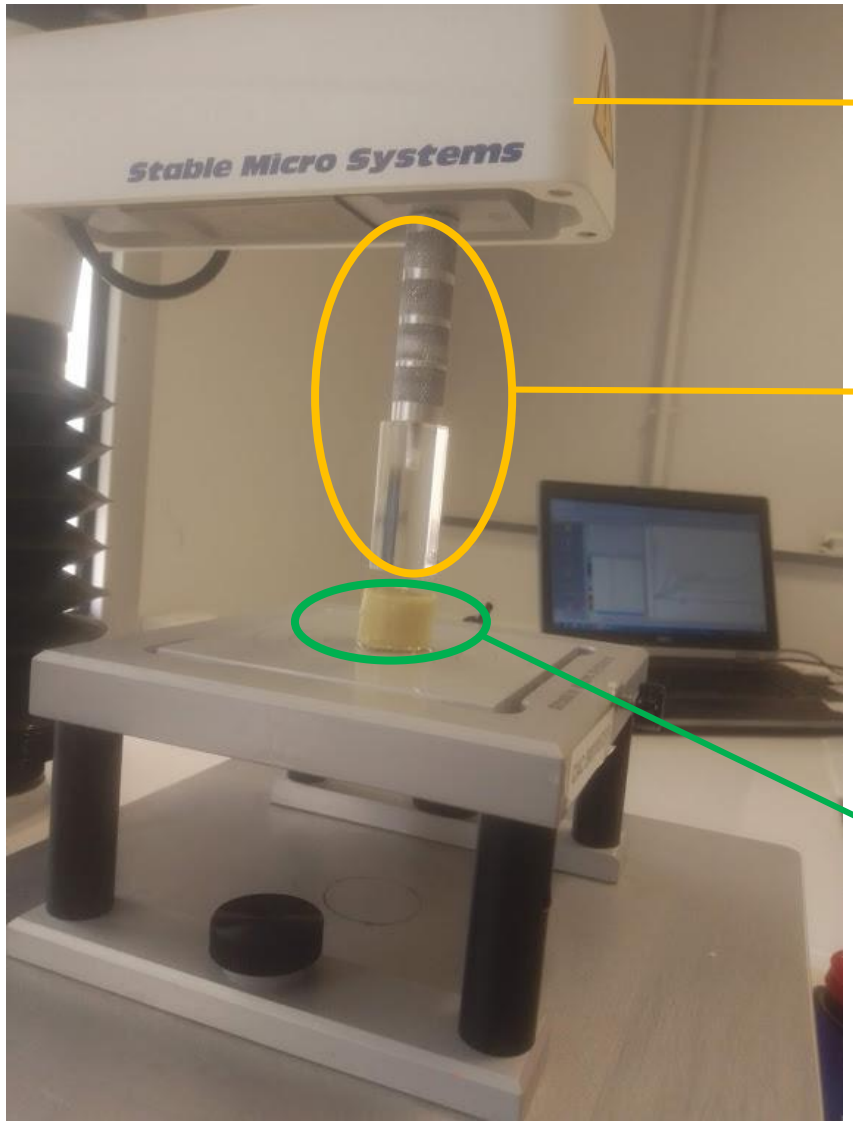
Conditions:

- Fixed surface area in contact with probe
- Fixed strain rate & test speed
- ‘‘No friction‘‘ - lubrication

**An Excel spreadsheet template is available for calculations

- The changes in force of deformation, time and distance are recorded.

SOP: Biaxial Extensional Viscosity



TAXT Texture analyzer

P/20P probe

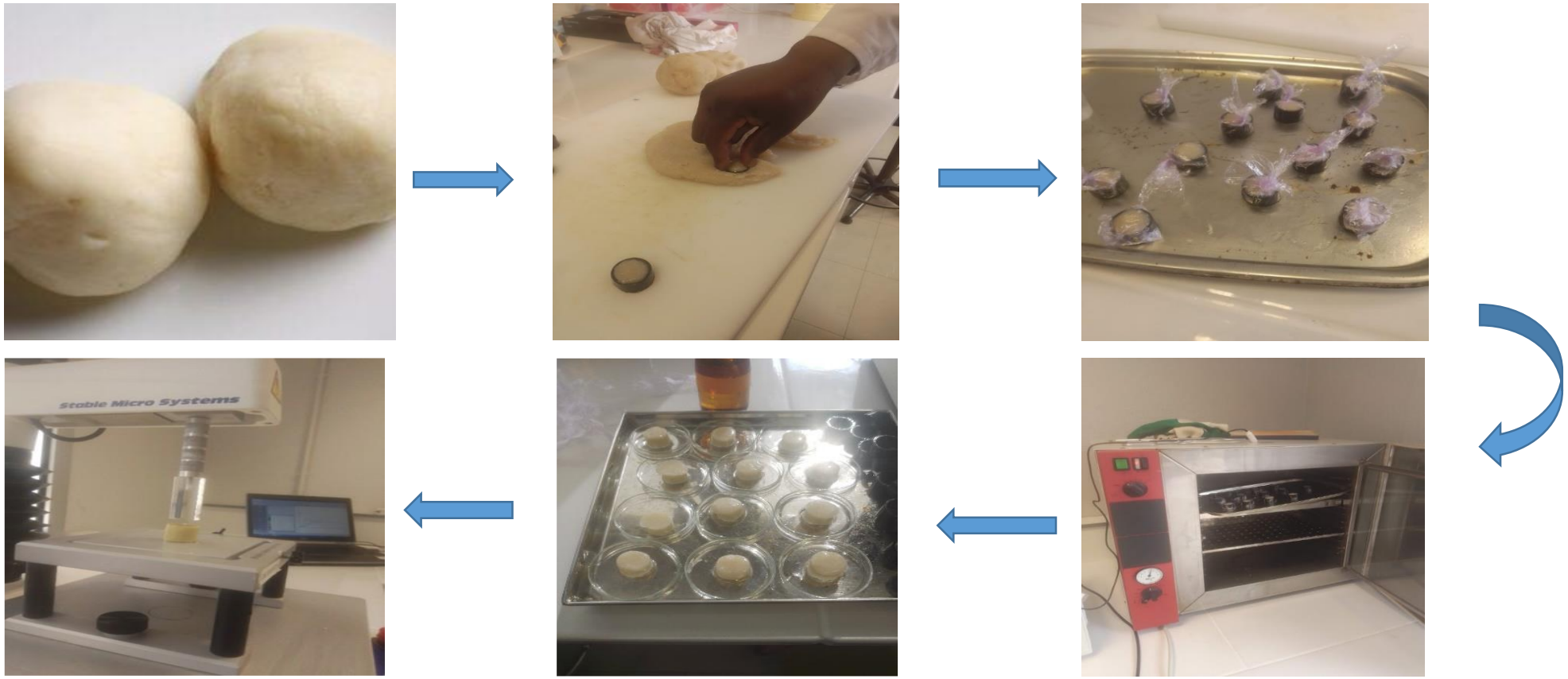
Sample

HDP/90 Platform

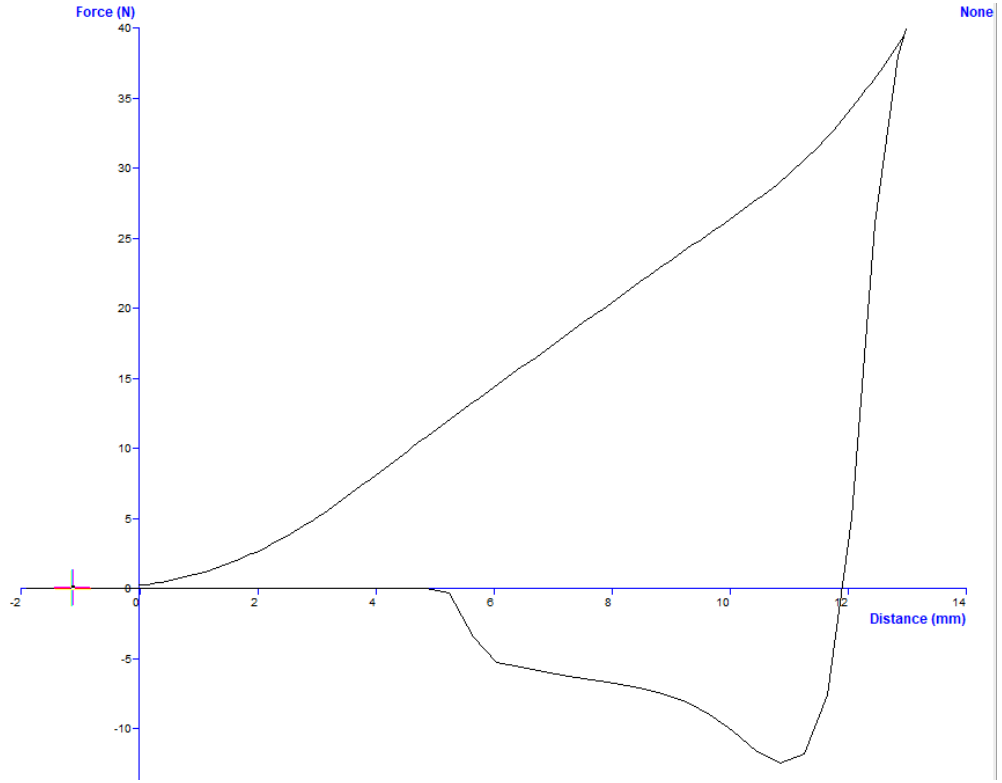
SOP: Biaxial Extensional Viscosity

- **Preparation of pounded yam dough** (SOP, Otegbayo et al. 2022)

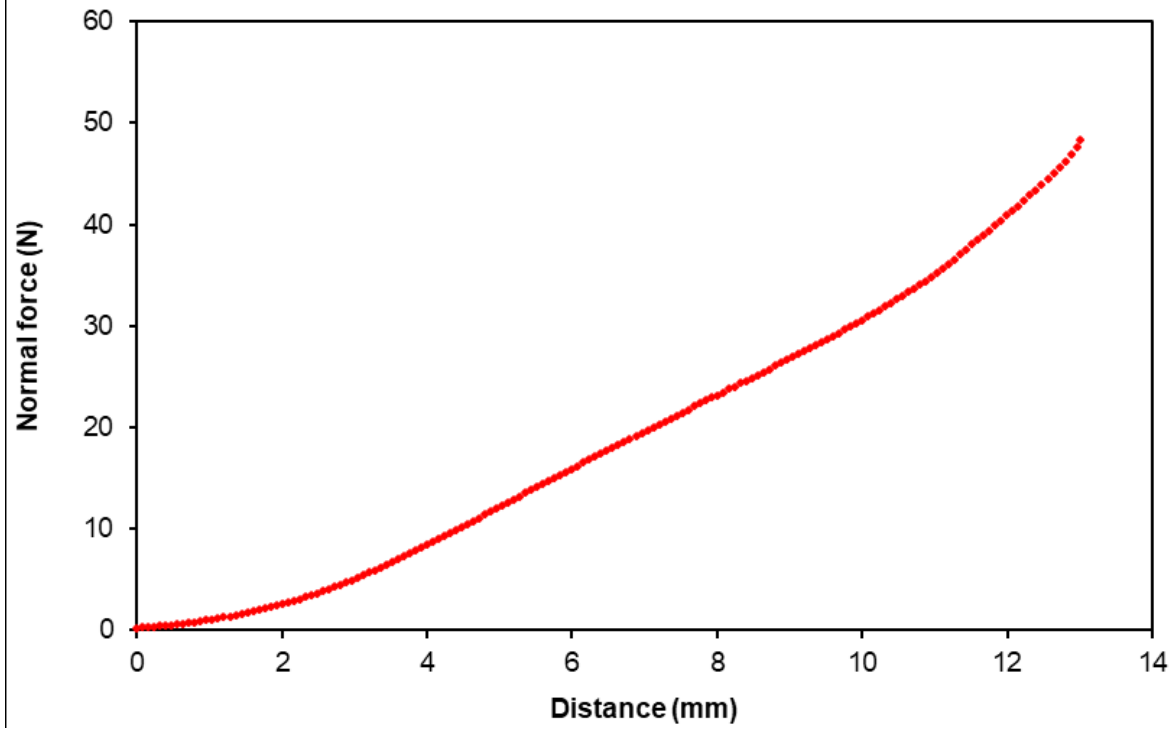
https://doi.org/10.18167/agritrop/00613



SOP: Biaxial Extensional Viscosity



Raw graph

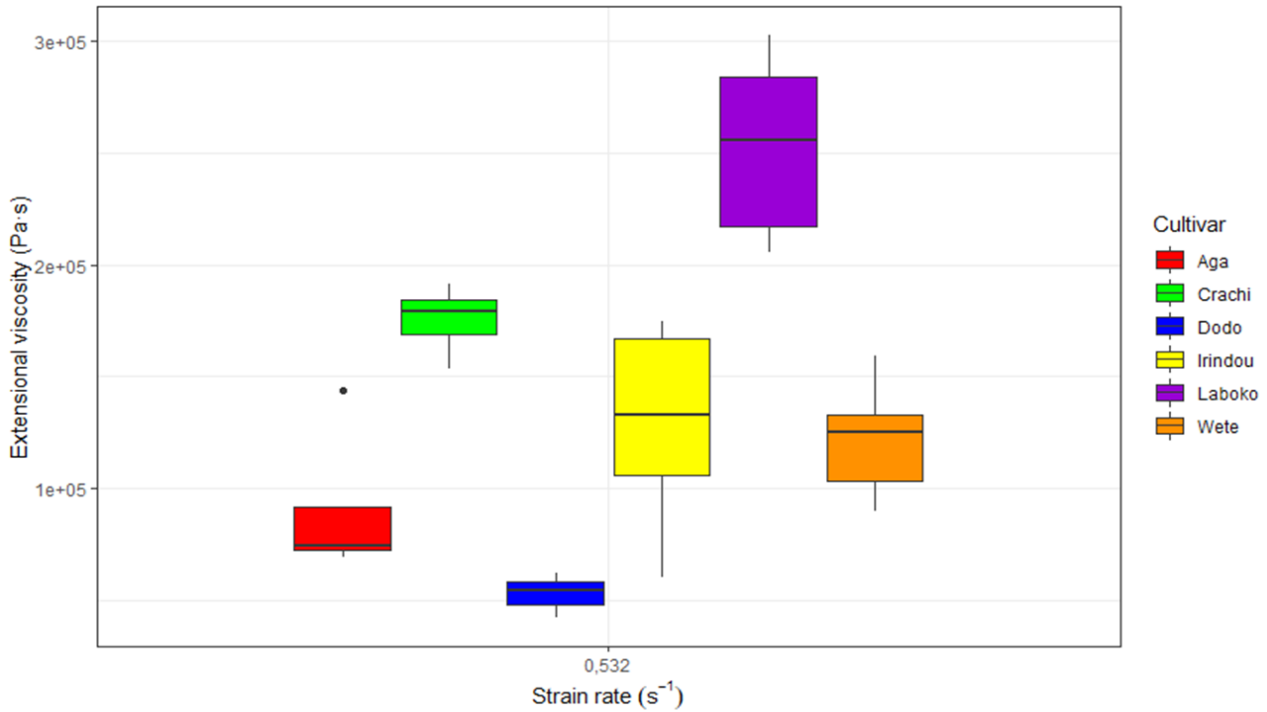


Processed, useful part of the graph

Critical point

**Advantage: The method can be used with food product profiles that fracture (brittle) easily or too adhesive, e.g. some *alata* species of yam, *eba*, *amala*.

SOP: Biaxial Extensional Viscosity

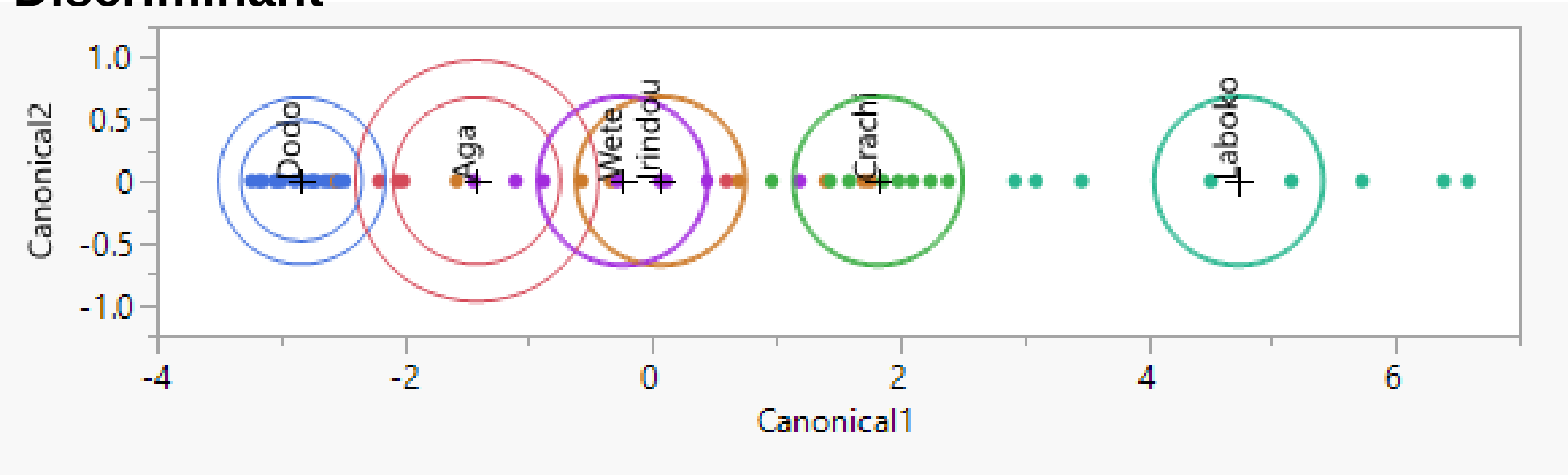


One-way Analysis of Variance – by genotypes (N = 6)

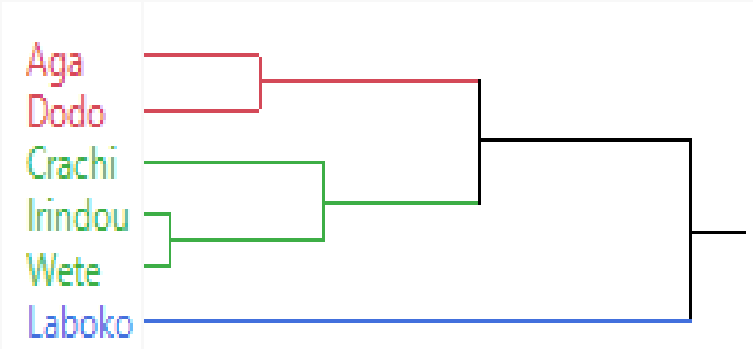
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Genotypes	5	$2.4x10^{11}$	$4.8x10^{10}$	68.5	3.61×10^{-20}
Cooking replicate	1	$7.2x10^{9}$	$7.2x10^{9}$	1.4	0.25

SOP: Biaxial Extensional Viscosity

Discriminant



Hierarchical



SOP: Biaxial Extensional Viscosity

- Correlations

Correlations

	hardness (N)	extensibility (mm)	area between to and Fmax (N.mm)	extensional viscosity (Pa.s)	stretchability	mouldability	consumer overall likeability
hardness (N)	1.0000	0.9928	0.9415	0.8266	0.9642	0.7053	0.8969
extensibility (mm)	0.9928	1.0000	0.9189	0.7750	0.9388	0.7844	0.8382
area between to and Fmax (N.mm)	0.9415	0.9189	1.0000	0.9570	0.8606	0.5383	0.9278
extensional viscosity (Pa.s)	0.8266	0.7750	0.9570	1.0000	0.7654	0.2715	0.9418
stretchability	0.9642	0.9388	0.8606	0.7654	1.0000	0.5964	0.9127
mouldability	0.7053	0.7844	0.5383	0.2715	0.5964	1.0000	0.3193
consumer overall likeability	0.8969	0.8382	0.9278	0.9418	0.9127	0.3193	1.0000

Correlation Probability

	hardness (N)	extensibility (mm)	area between to and Fmax (N.mm)	extensional viscosity (Pa.s)	stretchability	mouldability	consumer overall likeability
hardness (N)	<.0001	0.0072	0.0585	0.1734	0.0358	0.2947	0.1031
extensibility (mm)	0.0072	<.0001	0.0811	0.2250	0.0612	0.2156	0.1618
area between to and Fmax (N.mm)	0.0585	0.0811	<.0001	0.0430	0.1394	0.4617	0.0722
extensional viscosity (Pa.s)	0.1734	0.2250	0.0430	<.0001	0.2346	0.7285	0.0582
stretchability	0.0358	0.0612	0.1394	0.2346	<.0001	0.4036	0.0873
mouldability	0.2947	0.2156	0.4617	0.7285	0.4036	<.0001	0.6807
consumer overall likeability	0.1031	0.1618	0.0722	0.0582	0.0873	0.6807	<.0001

Significant correlations are highlighted. N = 5 genotypes. *Dodo* not included.

Future in perspective…

- Training partners on the 2 protocols (Sept & Oct) in readiness to screen yam populations with partners from new yam harvests (Nov) in BOWEN, IITA, NRCRI and Benin.
- Adapting the protocols to other product profiles *eba* (IITA) and *fufu*
- Completion of new SOP on boiled yam texture by extrusion in IITA.
- Participation in preparing 6 manuscript in JSFA special issue on RTBs
- Phase II RTBfoods Project: Effect of storage conditions on stretchability of pounded yam and key textural traits of boiled yam FPPs.

Acknowledgements

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