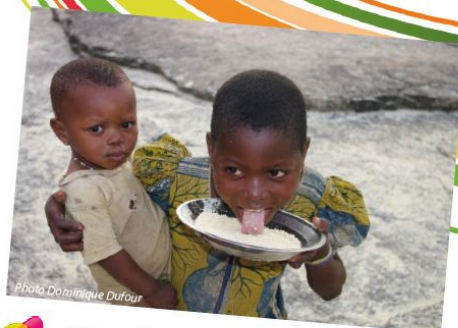# Technical & Support Mission Report for Validation of Instrumental Textural Characterization of Eba at IITA, Nigeria

Biophysical Characterization of Quality Traits, WP2

Ibadan, Nigeria, December 2021

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https://rtbfoods.cirad.fr

This report has been written in the framework of RTBfoods project.

To be cited as:

Ethics: The activities, which led to the production of this document, were assessed and approved by the CIRAD Ethics Committee (H2020 ethics self-assessment procedure). When relevant, samples were prepared according to good hygiene and manufacturing practices. When external participants were involved in an activity, they were priorly informed about the objective of the activity and explained that their participation was entirely voluntary, that they could stop the interview at any point and that their responses would be anonymous and securely stored by the research team for research purposes. Written consent (signature) was systematically sought from sensory panelists and from consumers participating in activities.

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This document has been reviewed by:		
Oluwatoyin AYETIGBO (CIRAD) Christian MESTRES (CIRAD)		10/03/2022 21/02/2022
Final validation by:		
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ABSTRACT

The SOP validation is aimed at establishing the veracity of the instrumental textural characterization protocol for *eba* using a texture analyser. Instrumental texture attributes such as hardness, adhesiveness, cohesiveness, springiness, chewiness, gumminess, and resilience were measured. A double compression mode was considered for the procedure as it simulates the action of the mastication of food.

Four cassava varieties with contrasting qualities were used to produce gari which was cooked to produce *eba*. Two sets of replicate measurements were made for a fixed cylindrical sample geometry (36 mm diameter, 22 mm height) at 35 °C, and a combination of measurement parameters (pre-test speed 1 mm/s, test speed 1.75 mm/s, strain 40 %, compression cycle interlude 10 s, aluminium compression probe 30 mm diameter). Statistical analyses of the data obtained assist to determine the accuracy of data and validity of the procedure for texture measurement. Analysis of variance (ANOVA) to determine effect of measurement variables and repeatability between replicate measurements were conducted. Also, discrimination between various cassava genotypes based on their textural attributes were determined from principal components (PCA), discriminant, and hierarchical analyses.

Context: Validation of SOP on Instrumental Texture Profile Analysis of *Eba*

Objectives: Evaluating repeatability between replicate measurements and discrimination between various cassava genotypes based on textural characteristics of *eba*

Key Words: Eba, Textural attributes, Principal components, Discriminant analysis, ANOVA, Texture analyser, Validation

1 GENERAL OVERVIEW

1.1 Interest of this support mission in RTBfoods framework

- Validation of SOP on instrumental textural characterization of *Eba*
- Knowledge share & transfer of SOP among partners

1.2 Specific objectives

1. Validation of SOP on instrumental textural characterization of *Eba* by testing protocol for accuracy, repeatability and discriminance.

1.3 Organizing committee

- Busie MAZIYA-DIXON, Food Scientist, International Institute of Tropical Agriculture, IITA
- Emmanuel ALAMU, Food Scientist, International Institute of Tropical Agriculture, IITA
- Michael Adesokan, Chemist, International Institute of Tropical Agriculture, IITA

1.4 Support team

NAME First name	Gender (F/M)	External OR Position / Responsibilities within RTBfoods (ex: WP leader, Product Champion)	Background – Expertise (ex: Biochemistry)	Institute / Company + Country	Email Contact	Consent to Picture use (YES/NO)
AYETIGBO Oluwatoyin	M	Focal Point, Texture	Food Science & Physical measurements	CIRAD, France	oluwatoyin.ayetigbo @cirad.fr	Yes

1.5 Targeted audience(s) & staff supported / trained

NAME First name	Gender (F/M)	Position	Education - Background (ex: Biochemistry)	Institute + Country	WP	Email Contact	Consent to Picture use (YES/NO)
ADESOKAN Michael	M	Lab manager	Chemistry	IITA, Nigeria	2	m.adesokan@ cgiar.org	Yes
OYEDELE Akeem	M	Assistant	-	IITA, Nigeria	2	oyedeleh@ gmail.com	Yes
FAWOLE Segun	M	Assistant	-	IITA, Nigeria	2	Segunfawole11 @gmail.com	Yes

1.6 Experience level of staff supported / trained

Michael Adesokan is the manager of the Food Science and crop utilization lab of IITA. He manages the lab, and is an expert on the texture measurement procedures.

Hakeem Oyedele and Segun Fawole are both skilled in the use of the texture analyser, and are the primary handlers of the texture analyser.

2 SUPPORT IMPLEMENTATION

2.1 Support mission agenda

29 November
• Arrival and familiarisation with staff, lab protocols and materials • Collection of the *gari* materials (produced from 4 contrasting cassava varieties in IITA) • Checking of the texture analyser if operational • Discussion on prior experimental challenges • Discussion with team and work plan breakdown for team members • Making sure of availability of all materials for start of measurements the following day
30 November
• Review of Draft SOP on texture and adjustment of some parameters • Calibration and setting measurement parameters of texture analyser • Sample preparation of *eba* following established SOP for *eba* preparation • Measurements on texture analyser (1 variety, 2 replicates per variety, 5 measurements per replicate)
1 December
• Calibration and setting measurement parameters of texture analyser • Sample preparation of *eba* following established SOP for *eba* preparation • Measurements on texture analyser (2 varieties, 2 replicates per variety, 5 measurements per replicate)
2 December
• Calibration and setting measurement parameters of texture analyser • Sample preparation of *eba* following established SOP for *eba* preparation • Measurements on texture analyser (1 variety, 2 replicates per variety, 5 measurements per replicate)
3 December
• Data download and reposition • Tentative discussion with team on results

2.2 Daily progress of the support mission

DAY 1

Who: Michael Adesokan, Segun Fawole

Where: Kitchen & Texture lab

What:
- Gari materials (from 4 contrasting cassava varieties) were collected from IITA lab Kitchen
- Introduction to assistants and lab management
- Laboratory protocol & safety introduction
- Brief review of staff competencies in texture measurements
- Checking the operationability of the texture analyser
- Draft of SOP shared

- Allocation of work duty to team members (1 eba preparation member, 1 texture measuring staff) for the smooth running of the work
- Checking availability of other accessories / materials

Specific Methods & Tools Used:

Discussions with lab management and assistants

Challenges Faced:

Team members complained of wrong Macro calculation of texture analyses output. Request was made to CIRAD, France, for alternative Macro add-in to be sent.

Output(s) – Result(s):

Gari materials and other materials prepared for following day. Work plan agreed on. SOP drafts shared

DAY 2

Who: Michael Adesokan, Segun Fawole, Hakeem Oyedele

Where: Kitchen & Texture lab

What:
- Texture analyser was calibrated with standard weight
- Texture measurement parameters were varied over some ranges of parameters (test speed and strain) to see which combination resulted in better statistical accuracy. Afterwards subsequent measurements were made at the selected parameters settings.
- Sample preparation was handled consistently by 1 person following the *Eba* sample preparation SOP. Samples prepared in batch as consistently as possible.
- Only 1 contrasting variety could be completed on day 2.
- Measurements were taken. Two replicates per variety, 5 measurements per replicate

Specific Methods & Tools Used:

- *Eba* sample preparation SOP, Texture SOP draft
- Double compression using texture analyser
- Hands-on activities

Challenges Faced:

Slight delay to start due to use of texture analyser by another project

Output(s) – Result(s):

Texture measurements raw data for 1 variety completed

DAY 3

Who: Michael Adesokan, Segun Fawole , Hakeem Oyedele

Where: Kitchen & Texture lab

What:
- Texture analyser was calibrated with standard weight
- Texture measurement parameters were set

- Sample preparation was handled consistently by 1 person following the *Eba* sample preparation SOP. Samples prepared in batch as consistently as possible.
- Only 2 contrasting variety could be completed on day 3.
- Measurements were taken. Two replicates per variety, 5 measurements per replicate

Specific Methods & Tools Used:

- *Eba* sample preparation SOP, Texture SOP draft
- Double compression using texture analyser
- Hands-on activities

Challenges Faced:

Wrong macro calculation of texture analyses output.

Output(s) – Result(s):

Texture measurements raw data for 2 varieties completed

DAY 4

Who: Michael Adesokan, Hakeem Oyedele

Where: Kitchen & Texture lab

What: -   Texture analyser was calibrated with standard weight
- Texture measurement parameters were set
- Sample preparation was handled consistently by 1 person following the *Eba* sample preparation SOP. Samples prepared in batch as consistently as possible.
- Only 1 contrasting variety was completed on day 4.
- Measurements were taken. Two replicates per variety, 5 measurements per replicate

Specific Methods & Tools Used:

- *Eba* sample preparation SOP, Texture SOP draft
- Double compression using texture analyser

Challenges Faced:

Wrong macro calculation of texture analyses output.

Output(s) – Result(s):

Texture measurements raw data for 1 variety completed

DAY 5

Who: Michael Adesokan, Segun Fawole , Hakeem Oyedele

Where: Texture lab

What:
- Data downloaded and stored for subsequent statistical analyses after Macro problem is resolved
- Tentative discussion with team on some results

Specific Methods & Tools Used:

- Discussions with team members on some prior results and on resolving Macro problems.

Challenges Faced:

- No final statistical analyses of all data collected could be conducted pending receiving a more accurate Macro calculation add-in from CIRAD France technical team
- Statistical PCA & discriminant analyses not fully understood by assisting members of the team

Output(s) – Result(s):

Texture measurements raw data for all varieties downloaded

2.3 List of material / documents distributed

- Validated SOP on sample preparation for *eba*
- Draft SOP on texture measurement of *eba*

2.4 General approach - methods applied

- Open discussion with lab manager, technical officer and an assistant.
- Hands-on activities

3 MISSION OUTPUTS & FEEDBACKS

3.1 Specific outputs of the support mission

- Statistically accurate textural attribute data were generated (see Appendix 1)
- ANOVA and repeatability of textural data was confirmed (see Appendix 1)
- The four selected varieties were well discriminated based on textural attributes (see Appendix 1)
- Number of measurements per replicate confirmed to be sufficient for discrimination
- The most discriminant attributes were identified among attributes list

3.2 Challenges faced – paths for improvement

- The problem of a faulty Macro producing wrong calculations. It was therefore recommended that recalculation of the outputs by using an efficient Macro be done. CIRAD France technical staff (Romain Domingo) were to assist in this regard
- The support staff are only partly skilled in statistical analyses for PCA, discriminance. A training may be recommended.
- Inability to determine a quality trait 'Stretchability' of *eba* by the protocol. CIRAD France technical staff were to assist in this regard

3.3 Feedbacks from staff trained - general remarks from support team

- Request for statistical training in cleaning textural data and statistical analyses (ANOVA, discriminance, PCA & hierarchical analyses)
- It was recommended that the gari samples be sent to CIRAD France for development of a protocol to determine the attribute 'Stretchability'.
- A more accurate macro was requested by the partner team

3.4 Next steps

- Texture Profile analyses of a wider range of eba samples from more cassava varieties
- A more accurate Macro calculation will be required for recalculation
- Training may be planned to acquaint team members with statistical analyses on PCA, discriminant and hierarchical analyses

List of documents attached to the report

1. SOP drafts for sample preparation and texture measurement	**Yes**
2. Pictures	**No**

4 APPENDICES

4.1 Annex 1: Statistical accuracy, ANOVA, repeatability and discriminance of texture of *Eba* at validation exercise

Varieties code:

- WP5 302 – poor elite variety
- WP5 306 – good elite variety
- WP5 307 – intermediate elite variety
- WP5 308 – intermediate elite variety

Procedure:

Texture measurements using the texture analyser (TPA compression method) was carried out by preparing *eba* based on the SOP for preparation of *eba* (RTBfoods_E.6.7_SOP) used with modifications. Two preparations or cooking replicates per variety were considered and 5 measurements per cooking replicate were collected. Measurements were made at 35°C.

	Variety	N	Mean	Std Error	CV
Hardness	WP5 302	10	456	10	6.6
	WP5 306	10	430	16	11.5
	WP5 307	10	411	10	7.4
	WP5 308	10	363	10	8.8
Adhesiveness	WP5 302	10	-472	86	-57.6
	WP5 306	10	-387	52	-42.6
	WP5 307	10	-547	50	-28.9
	WP5 308	10	-338	48	-44.8
Cohesiveness	WP5 302	10	0.37	0.0	6.8
	WP5 306	10	0.34	0.0	7.5
	WP5 307	10	0.45	0.0	7.2
	WP5 308	10	0.42	0.0	11.7
Springiness	WP5 302	10	26	4.2	51.6
	WP5 306	10	27	0.9	11.1
	WP5 307	10	42	1.3	9.8
	WP5 308	10	36	3.5	30.8
Gumminess	WP5 302	10	167	4.4	8.3
	WP5 306	10	146	6.3	13.8
	WP5 307	10	183	5.8	10
	WP5 308	10	151	7.9	16.5
Chewiness	WP5 302	10	44	7.7	54.7
	WP5 306	10	39	2.8	22.5
	WP5 307	10	78	4.6	18.7
	WP5 308	10	57	7.1	39.4
Resilience	WP5 302	10	5.0	0.1	8.3

	Variety	N	Mean	Std Error	CV
	WP5 306	10	6.3	0.1	6
	WP5 307	10	5.8	0.1	4.6
	WP5 308	10	5.6	0.1	7.1

NB: The data in the table above was calculated when outliers were not removed. Outliers can be removed by statistical analysis.

Analysis of Variance by variety and cooking replicate

Hardness

By Variety	By cooking replicate

By Variety

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Variety	3	46633.222	15544.4	11.7365	<.0001*
Error	36	47680.105	1324.4		
C. Total	39	94313.327			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
WP5 302	10	456.4661	30.248476	9.565408	434.82764	478.10456
WP5 306	10	429.8005	49.331532	15.6	394.51085	465.09015
WP5 307	10	410.8339	30.477931	9.6379681	389.0313	432.6365
WP5 308	10	362.9666	31.942366	10.101063	340.11641	385.81679

Connecting Letters Report

Level			Mean
WP5 302	A		456.46610
WP5 306	A	B	429.80050
WP5 307		B	410.83390
WP5 308		C	362.96660

Levels not connected by same letter are significantly different.

Ordered Differences Report

Level	- Level	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
WP5 302	WP5 308	93.49950	16.27543	49.6661	137.3329	<.0001*
WP5 306	WP5 308	66.83390	16.27543	23.0005	110.6673	0.0012*
WP5 307	WP5 308	47.86730	16.27543	4.0339	91.7007	0.0278*
WP5 302	WP5 307	45.63220	16.27543	1.7988	89.4656	0.0387*
WP5 302	WP5 306	26.66560	16.27543	-17.1678	70.4990	0.3706
WP5 306	WP5 307	18.96660	16.27543	-24.8668	62.8000	0.6521

By cooking replicate

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Cooking replicate	1	5246.413	5246.41	2.2384	0.1429
Error	38	89066.914	2343.87		
C. Total	39	94313.327			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
1	20	403.56425	50.689814	11.334587	379.84069	427.28781
2	20	426.4693	46.024722	10.291441	404.92907	448.00953

Connecting Letters Report

Level		Mean
2	A	426.46930
1	A	403.56425

Levels not connected by same letter are significantly different.

Ordered Differences Report

Level	- Level	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
2	1	22.90505	15.30969	-8.08813	53.89823	0.1429

Adhesiveness

By Variety	By cooking replicate

By Variety

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Variety	3	256669.8	85556.6	2.2954	0.0942
Error	36	1341805.3	37272.4		
C. Total	39	1598475.1			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
WP5 302	10	-472.327	272.06492	86.034481	-666.9505	-277.7035
WP5 306	10	-386.6175	164.53076	52.029195	-504.3157	-268.9193
WP5 307	10	-547.1223	158.3008	50.05911	-660.3639	-433.8807
WP5 308	10	-338.2219	151.46169	47.896392	-446.5711	-229.8727

By cooking replicate

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Cooking replicate	1	65551.8	65551.8	1.6250	0.2101
Error	38	1532923.4	40340.1		
C. Total	39	1598475.1			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
1	20	-476.5542	194.0605	43.393248	-567.3773	-385.7311
2	20	-395.5902	207.41432	46.379251	-492.663	-298.5173

By Variety	By cooking replicate

By Variety

Connecting Letters Report

Level		Mean
WP5 308	A	-338.2219
WP5 306	A	-386.6175
WP5 302	A	-472.3270
WP5 307	A	-547.1223

Levels not connected by same letter are significantly different.

Ordered Differences Report

Level	- Level	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
WP5 308	WP5 307	208.9004	86.33930	-23.631	441.4318	0.0914
WP5 306	WP5 307	160.5048	86.33930	-72.027	393.0362	0.2635
WP5 308	WP5 302	134.1051	86.33930	-98.426	366.6365	0.4175
WP5 306	WP5 302	85.7095	86.33930	-146.822	318.2409	0.7545
WP5 302	WP5 307	74.7953	86.33930	-157.736	307.3267	0.8221
WP5 308	WP5 306	48.3956	86.33930	-184.136	280.9270	0.9430

By cooking replicate

Connecting Letters Report

Level		Mean
2	A	-395.5902
1	A	-476.5542

Levels not connected by same letter are significantly different.

Ordered Differences Report

Level	- Level	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
2	1	80.96405	63.51385	-47.6144	209.5425	0.2101

Cohesiveness

By Variety

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Variety	3	0.06809410	0.022698	19.5141	<.0001*
Error	36	0.04187380	0.001163		
C. Total	39	0.10996790			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
WP5 302	10	0.3672	0.0250013	0.0079061	0.3493151	0.3850849
WP5 306	10	0.3386	0.0255177	0.0080694	0.3203457	0.3568543
WP5 307	10	0.4451	0.0321851	0.0101778	0.4220762	0.4681238
WP5 308	10	0.4149	0.0483792	0.0152988	0.3802916	0.4495084

Connecting Letters Report

Level			Mean
WP5 307	A		0.44510000
WP5 308	A		0.41490000
WP5 302		B	0.36720000
WP5 306		B	0.33860000

Levels not connected by same letter are significantly different.

Ordered Differences Report

Level	- Level	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
WP5 307	WP5 306	0.1065000	0.0152523	0.065422	0.1475779	<.0001*
WP5 307	WP5 302	0.0779000	0.0152523	0.036822	0.1189779	<.0001*
WP5 308	WP5 306	0.0763000	0.0152523	0.035222	0.1173779	<.0001*
WP5 308	WP5 302	0.0477000	0.0152523	0.006622	0.0887779	0.0175*
WP5 307	WP5 308	0.0302000	0.0152523	-0.010878	0.0712779	0.2143
WP5 302	WP5 306	0.0286000	0.0152523	-0.012478	0.0696779	0.2565

By cooking replicate

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Cooking replicate	1	0.00104040	0.001040	0.3629	0.5505
Error	38	0.10892750	0.002867		
C. Total	39	0.10996790			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
1	20	0.38635	0.0535235	0.0119682	0.3613002	0.4113998
2	20	0.39655	0.0535561	0.0119755	0.371485	0.421615

Connecting Letters Report

Level		Mean
2	A	0.39655000
1	A	0.38635000

Levels not connected by same letter are significantly different.

Ordered Differences Report

Level	- Level	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
2	1	0.0102000	0.0169308	-0.024075	0.0444749	0.5505

Springiness

By Variety	By cooking replicate

By Variety

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Variety	3	1873.1152	624.372	7.6748	0.0004*
Error	36	2928.7433	81.354		
C. Total	39	4801.8585			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
WP5 302	10	25.6164	13.214601	4.1788236	16.163244	35.069556
WP5 306	10	26.8156	2.9690354	0.9388914	24.69168	28.93952
WP5 307	10	42.159	4.1194845	1.3026954	39.212098	45.105902
WP5 308	10	36.3108	11.180561	3.5356037	28.312709	44.308891

Connecting Letters Report

Level			Mean
WP5 307	A		42.159000
WP5 308	A	B	36.310800
WP5 306		B	26.815600
WP5 302		B	25.616400

Levels not connected by same letter are significantly different.

Ordered Differences Report

Level	- Level	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
WP5 307	WP5 302	16.54260	4.033708	5.67891	27.40629	0.0012*
WP5 307	WP5 306	15.34340	4.033708	4.47971	26.20709	0.0029*
WP5 308	WP5 302	10.69440	4.033708	-0.16929	21.55809	0.0550
WP5 308	WP5 306	9.49520	4.033708	-1.36849	20.35889	0.1048
WP5 307	WP5 308	5.84820	4.033708	-5.01549	16.71189	0.4776
WP5 306	WP5 302	1.19920	4.033708	-9.66449	12.06289	0.9907

By cooking replicate

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Cooking replicate	1	0.7969	0.797	0.0063	0.9371
Error	38	4801.0616	126.344		
C. Total	39	4801.8585			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
1	20	32.5843	10.95853	2.4504019	27.45555	37.71305
2	20	32.8666	11.515123	2.5748599	27.477356	38.255844

Connecting Letters Report

Level		Mean
2	A	32.866600
1	A	32.584300

Levels not connected by same letter are significantly different.

Ordered Differences Report

Level	- Level	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
2	1	0.2823000	3.554486	-6.91346	7.478058	0.9371

Gumminess

By Variety	By cooking replicate

By Variety

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Variety	3	8469.558	2823.19	7.2925	0.0006*
Error	36	13936.931	387.14		
C. Total	39	22406.489			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
WP5 302	10	167.4551	13.921594	4.4023946	157.49619	177.41401
WP5 306	10	145.6387	20.055147	6.3419942	131.29211	159.98529
WP5 307	10	182.803	18.223101	5.7626505	169.76698	195.83902
WP5 308	10	151.1856	24.90877	7.8768447	133.36694	169.00426

Connecting Letters Report

Level			Mean
WP5 307	A		182.80300
WP5 302	A	B	167.45510
WP5 308		B	151.18560
WP5 306		B	145.63870

Levels not connected by same letter are significantly different.

By cooking replicate

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Cooking replicate	1	1442.713	1442.71	2.6151	0.1141
Error	38	20963.776	551.68		
C. Total	39	22406.489			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
1	20	155.76495	27.251925	6.0937157	143.01066	168.51924
2	20	167.77625	18.99182	4.2467	158.8878	176.6647

Connecting Letters Report

Level		Mean
2	A	167.77625
1	A	155.76495

Levels not connected by same letter are significantly different.

By Variety

Ordered Differences Report

Level	- Level	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
WP5 307	WP5 306	37.16430	8.799284	13.4658	60.86278	0.0009*
WP5 307	WP5 308	31.61740	8.799284	7.9189	55.31588	0.0051*
WP5 302	WP5 306	21.81640	8.799284	-1.8821	45.51488	0.0804
WP5 302	WP5 308	16.26950	8.799284	-7.4290	39.96798	0.2679
WP5 307	WP5 302	15.34790	8.799284	-8.3506	39.04638	0.3165
WP5 308	WP5 306	5.54690	8.799284	-18.1516	29.24538	0.9216

By cooking replicate

Ordered Differences Report

Level	- Level	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
2	1	12.01130	7.427505	-3.02506	27.04766	0.1141

Chewiness

By Variety

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Variety	3	8766.643	2922.21	8.5122	0.0002*
Error	36	12358.638	343.30		
C. Total	39	21125.282			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
WP5 302	10	44.1962	24.19149	7.6500209	26.89065	61.50175
WP5 306	10	39.3931	8.875453	2.8066647	33.043983	45.742217
WP5 307	10	77.6848	14.544796	4.5994682	67.28008	88.08952
WP5 308	10	56.6779	22.307602	7.0542831	40.720003	72.635797

Connecting Letters Report

Level			Mean
WP5 307	A		77.684800
WP5 308	A	B	56.677900
WP5 302		B	44.196200
WP5 306		B	39.393100

Levels not connected by same letter are significantly different.

Ordered Differences Report

Level	- Level	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
WP5 307	WP5 306	38.29170	8.286079	15.9754	60.60800	0.0003*
WP5 307	WP5 302	33.48860	8.286079	11.1723	55.80490	0.0015*
WP5 307	WP5 308	21.00690	8.286079	-1.3094	43.32320	0.0713
WP5 308	WP5 306	17.28480	8.286079	-5.0315	39.60110	0.1770
WP5 308	WP5 302	12.48170	8.286079	-9.8346	34.79800	0.4443
WP5 302	WP5 306	4.80310	8.286079	-17.5132	27.11940	0.9375

By cooking replicate

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Cooking replicate	1	135.240	135.240	0.2448	0.6236
Error	38	20990.042	552.370		
C. Total	39	21125.282			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
1	20	52.64925	23.488787	5.2522524	41.656159	63.642341
2	20	56.32675	23.516291	5.2584025	45.320787	67.332713

Connecting Letters Report

Level		Mean
2	A	56.326750
1	A	52.649250

Levels not connected by same letter are significantly different.

Ordered Differences Report

Level	- Level	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
2	1	3.677500	7.432157	-11.3683	18.72327	0.6236

Resilience

By Variety

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Variety	3	7.657589	2.55253	18.8837	<.0001*
Error	36	4.866161	0.13517		
C. Total	39	12.523750			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
WP5 302	10	5.0336	0.4173004	0.131962	4.7350813	5.3321187
WP5 306	10	6.2508	0.3746583	0.1184774	5.9827856	6.5188144
WP5 307	10	5.7753	0.2628684	0.0831263	5.5872553	5.9633447
WP5 308	10	5.5541	0.3963286	0.1253301	5.2705836	5.8376164

By cooking replicate

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
Cooking replicate	1	0.656384	0.656384	2.1018	0.1553
Error	38	11.867365	0.312299		
C. Total	39	12.523750			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
1	20	5.52535	0.5999073	0.1341433	5.2445847	5.8061153
2	20	5.78155	0.5144992	0.1150455	5.540757	6.022343

By Variety								By cooking replicate						

By Variety

Connecting Letters Report

Level				Mean
WP5 306	A			6.2508000
WP5 307		B		5.7753000
WP5 308		B		5.5541000
WP5 302			C	5.0336000

Levels not connected by same letter are significantly different.

Ordered Differences Report

Level	- Level	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
WP5 306	WP5 302	1.217200	0.1644209	0.774377	1.660023	<.0001*
WP5 307	WP5 302	0.741700	0.1644209	0.298877	1.184523	0.0004*
WP5 306	WP5 308	0.696700	0.1644209	0.253877	1.139523	0.0008*
WP5 308	WP5 302	0.520500	0.1644209	0.077677	0.963323	0.0159*
WP5 306	WP5 307	0.475500	0.1644209	0.032677	0.918323	0.0313*
WP5 307	WP5 308	0.221200	0.1644209	-0.221623	0.664023	0.5410

By cooking replicate

Connecting Letters Report

Level		Mean
2	A	5.7815500
1	A	5.5253500

Levels not connected by same letter are significantly different.

Ordered Differences Report

Level	- Level	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
2	1	0.2562000	0.1767199	-0.101554	0.6139545	0.1553

The textural attributes for the varieties showed good repeatability with no significant differences between the cooking replicate means. Generally, ANOVA reveals significant differences between varieties based on all the textural parameters (except Adhesiveness).

Correlation coefficient
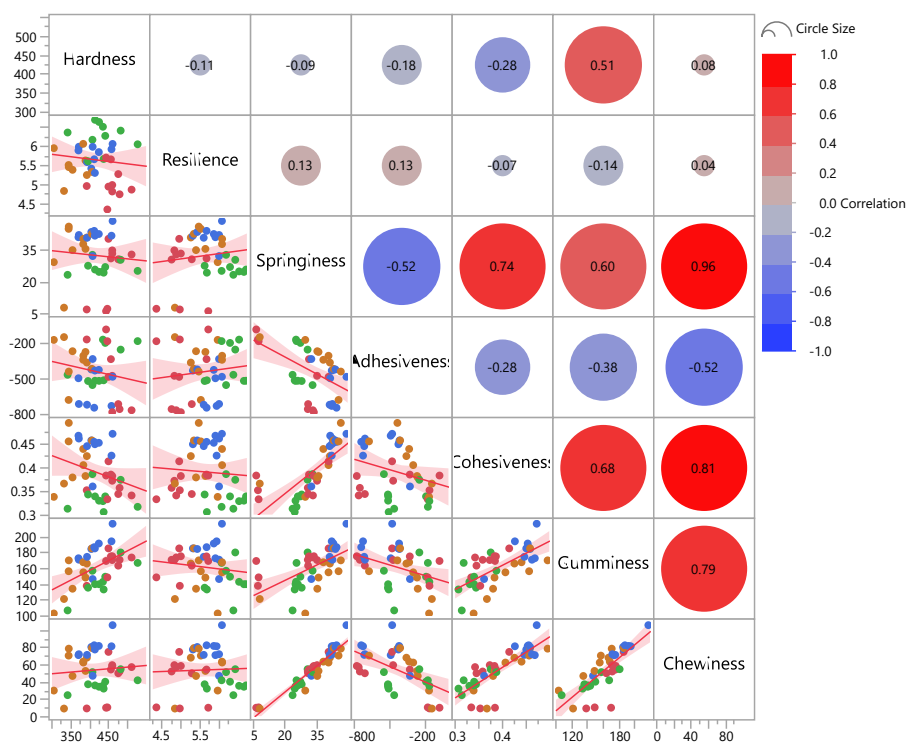
Correlation Probability

	Hardness	Resilience	Springiness	Adhesiveness	Cohesiveness	Gumminess	Chewiness
Hardness	<.0001						
Resilience	0.5010	<.0001					
Springiness	0.5963	0.4347	<.0001				
Adhesiveness	0.2701	0.4420	0.0005	<.0001			
Cohesiveness	0.0824	0.6473	<.0001	0.0799	<.0001		
Gumminess	0.0008	0.3886	<.0001	0.0154	<.0001	<.0001	
Chewiness	0.6170	0.8114	<.0001	0.0006	<.0001	<.0001	<.0001

Correlations between instrumental textural attributes

Considering correlations between the instrumental textural attributes based on individual measurements of cooking replicate values, the results below were obtained, showing significant correlations between a number of attribute pairs.

Significant correlations were found between the following pairs of attributes:

- Hardness & Gumminess (r = 0.51)
- Springiness & cohesiveness (r = 0.74)
- Springiness & Adhesiveness (r = -0.52)
- Springiness & Gumminess (r = 0.60)
- Springiness & Chewiness (r = 0.96)
- Adhesiveness & Chewiness (r = -0.52)
- Adhesiveness & Gumminess (r = -0.38)
- Cohesiveness & Gumminess (r = 0.68)
- Cohesiveness & Chewiness (r = 0.81)
- Gumminess & Chewiness (r = 0.79)

## Discriminance between varieties based on textural profile

|	N	Mean value	Min of mean value	Max of mean value	Std Err	P-value
Hardness	40	415	353	456	8	<0.0001**
Adhesiveness	40	-436	-780	-82	32	0.0942
Cohesiveness	40	0.4	0.3	0.5	0.0	<0.0001**
Springiness	40	33	6	49	2	0.0004**
Gumminess	40	162	103	217	4	0.0006**
Chewiness	40	54	10	106	4	0.0002**
Resilience	40	6	4	6.71	0.1	<0.0001**

** Significant at 5 % level
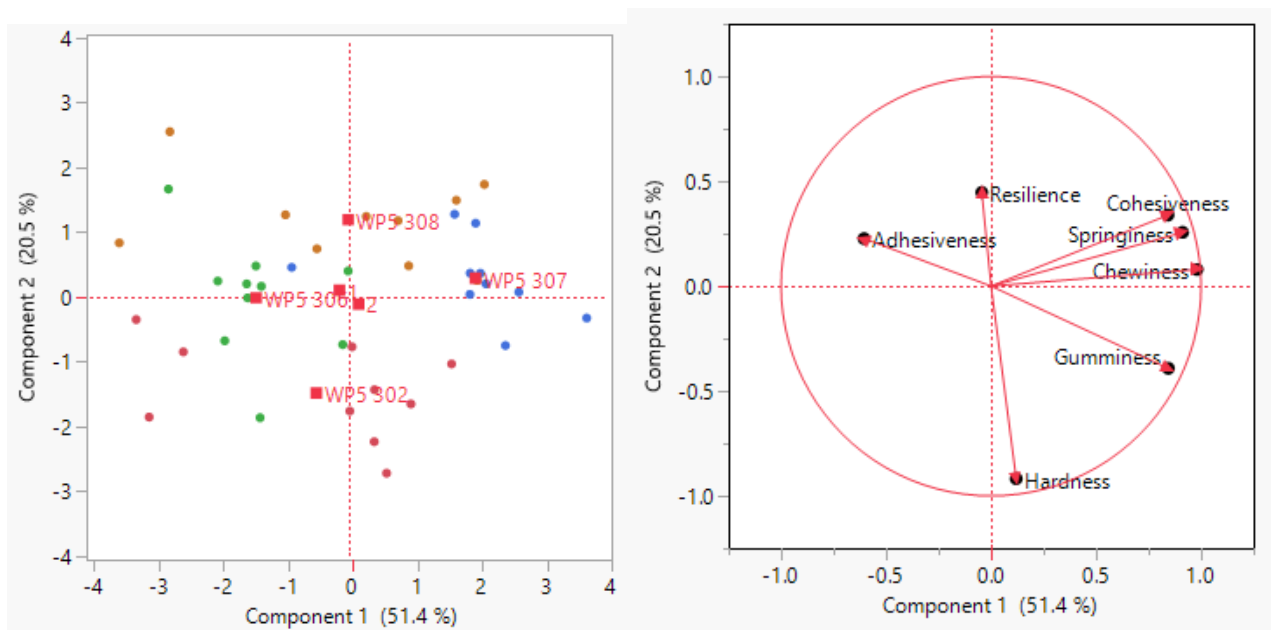
PCA

The first two components of the score plot of the PCA explained 71.9 % of the variation. The PCA shows that the varieties were fairly grouped separately between the components, thereby showing differences between the varieties' textural attributes. The textural quality attributes that contribute the most to variation among the varieties are chewiness, springiness, cohesiveness, gumminess and hardness.
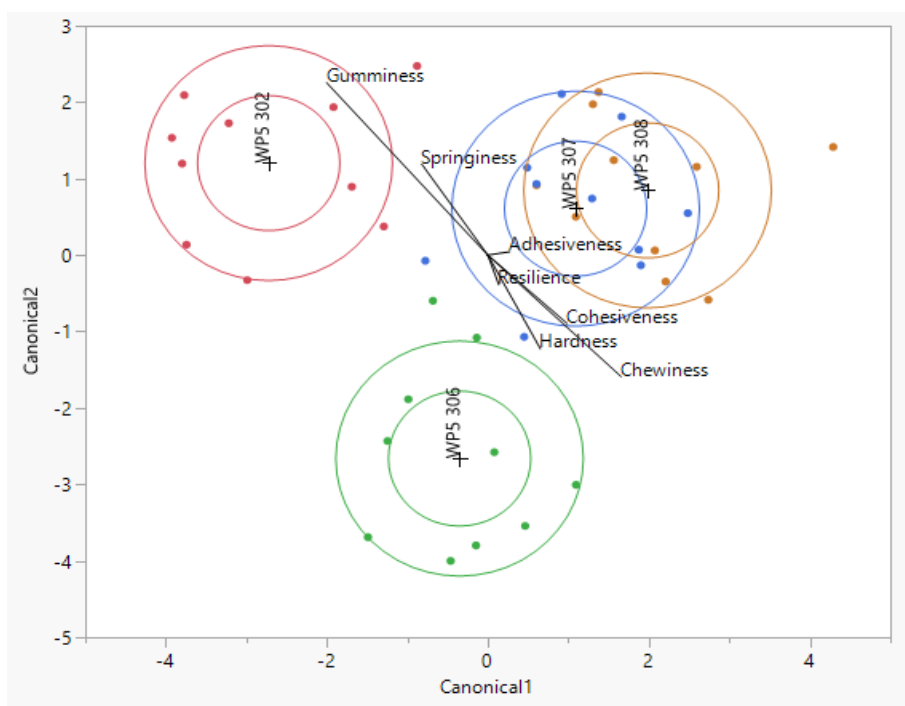
Discriminance

The first 2 canonicals explain 87.9 % of the variations. The varieties were grouped separately in the canonical space, but there was an interlope between WP5 307 and WP5 308 since both varieties are considered of intermediate quality for making *eba*. Discriminant analysis shows that

cohesiveness, chewiness, hardness, springiness and gumminess carry more weights in discriminating between the varieties. Resilience and Adhesiveness have poorer discriminating power.
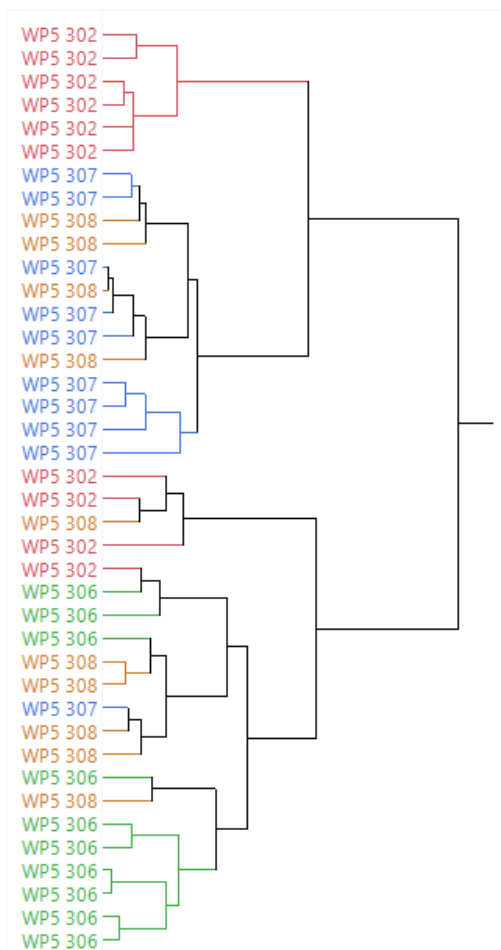
Hierarchical classes

The varieties were classified into groups within the hierarchical pattern, but there were some interruptions of WP5 307 and WP5 308 within the groups of WP5 302 and WP5 306.

Conclusion

Cooking replication did not have a significant effect on the textural attributes of the varieties. However, significant varietal effects on textural attributes were found. Instrumental texture profile using texture analyser may be considered as a tool to discriminate the textural attributes of eba made from various cassava genotypes. Particularly, the hardness, cohesiveness, gumminess, springiness and chewiness are most discriminatory. A minimum of 2 cooking replicates and about 5 measurements per replicate is sufficient for discrimination between varieties.

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