Training Report

Technical & Support Mission Report for Validation of Instrumental Textural Characterization of Fufu at NRCRI, Nigeria

Biophysical Characterization of Quality Traits, WP2

Umudike, Nigeria, December 2021

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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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ABSTRACT

The SOP validation, briefly, is aimed at confirmation of experimental outcomes of prior instrumental measurement of texture attributes of fufu, by testing the current generated data for agreement with prior measurements. Instrumental texture attributes such as hardness, adhesiveness, cohesiveness, springiness, gumminess, chewiness and resilience were measured using a texture analyser. A double compression mode was considered for the procedure as it simulates the action of the mastication of food.

Fermented cassava mash with contrasting cooking qualities obtained from three varieties of cassava were used to produce fufu. Two sets of replicate measurements were made for a fixed cylindrical sample geometry (40 mm x 47 mm) at 45 °C, and a combination of measurement parameters (pre-test speed 1mm/s, test speed 2 mm/s, strain 30%, compression cycle interlude 10 s, compression probe 100 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 inherent textural attributes were viewed from principal components (PCA), discriminant, and hierarchical analyses.

Context: Validation of SOP on Instrumental Texture Profile Analysis of Fufu

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

Key Words: Textural attributes, PCA, Discriminant analysis, ANOVA, Fufu, Texture analyser, Hierarchical classification

1 GENERAL OVERVIEW

1.1 Interest of this support mission in RTBfoods framework

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

1.2 Specific objectives

- Validation of SOP on instrumental textural characterization of fufu by testing protocol for accuracy, repeatability and discriminance.

1.3 Organizing committee

- Ugo CHIJIOKE, Food Technologist, National Roots Crop Research Institute (NRCRI)

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	Institute + COUNTRY	WP	Email Contact	Consent to Picture use (YES/NO)
1	CHIJIOKE Ugo	F	Food Scientist / Lead	Food Science	NRCRI Nigeria	2	ugochijioke4@gmail.com	YES
2	OKORONKWO Justice	M	Technical Official	Biochemistry	NRCRI Nigeria	2	justice_okoronkwo@yahoo.com	YES
3	ACHONWA Oluchi	F	Assistant	Food Science	NRCRI Nigeria	2	olyachonwa@gmail.com	YES
4	IRO Ugochi Jane	F	Assistant	-	NRCRI Nigeria	2	ugochijaneiro@gmail.com	YES
5	UDOKA Precious	F	Assistant	-	NRCRI Nigeria	2	preudoka@yahoo.com	YES
6	CHIKERE Juliet	F	Assistant	-	NRCRI Nigeria	2	-	YES
7	OGUNKA Amaka	F	Assistant	-	NRCRI Nigeria	2	Pinozichora268@gmail.com	YES

1.6 Experience level of staff supported / trained

Ugo Chijioke is the lead Food Scientist at the Institute. She manages the lab, and has good knowledge on the texture measurement procedures.

Okoronkwo Justice is the primary technical officer focussed on the use of the texture analyser.

Oluchi Achonwa is the assistant to primary technical officer and focussed on assisting on the use of the texture analyser

Other assisting staff have varying skills such as in sample preparation prior to textural measurement.

2 SUPPORT IMPLEMENTATION

2.1 Support mission agenda

13 December
• Arrival and familiarisation with staff, lab protocol and materials • Test run of the texture analyser • Conditioning of test materials (fermented cassava mash from 3 contrasting varieties of cassava) • Discussion on prior experimental data (4 varieties, 2 replicates per variety, 5 measurements per replicate) • Discussion with team and work plan breakdown • Making sure of availability of all materials for start of measurements the following day
14 December
• Sample preparation of fufu from cooked mash following established SOP for fufu preparation • Calibration and setting measurement parameters of texture analyser • Measurements on texture analyser (2 varieties, 2 replicates per variety, 6 measurements per replicate)
15 December
• Sample preparation of fufu from cooked mash following established SOP for fufu preparation • Calibration and setting measurement parameters of texture analyser • Measurements on texture analyser (1 variety, 2 replicates per variety, 6 measurements per replicate) • Data download and reposition • Tentative discussion with team on results • Preparation for analyses on next food product profile to be tested (boiled yam)

2.2 Daily progress of the support mission

DAY 1

Who: Ugo, Justice, Jane, Precious, Amaka

Where: Sample preparation room and Texture lab.

What:
- Introduction to staff member and assistants.
- Laboratory protocol, safety introduction.
- Review of staff competencies in texture measurements.
- Test running the texture analyser.
- Allocation of work duty to team members (fufu preparers, texture measuring staff, and other auxiliary functions for the smooth running of the work).

- 3 contrasting fermented fufu mash samples were conditioned at room temperature overnight.
- Draft of SOP shared.

Specific Methods & Tools Used:

Discussions

Challenges Faced:

- Problem with steady electricity. Therefore, the team manager planned fuelling and use of stand-by generator for the following day to prevent shutdown of the texture analyses system during activity.
- Institute was on strike and access was delayed into building.

Output(s) – Result(s):

Work plan agreed to avoid delays and electricity shutdown.

DAY 2

Who: Ugo, Justice, Oluchi, Jane, Precious, Amaka

Where: Sample preparation room and Texture lab.

What:

- Texture SOP draft copy shared
- Texture analyser was calibrated with standard weight (2kg)
- Texture measurement parameters set (See SOP deliverables for details)
- Appropriate use of infrared thermometer
- Sample preparation was handled consistently by 2 assistants following fufu sample preparation SOP. Samples prepared in batch as consistently as possible.
- Only 2 contrasting varieties could be completed. Third variety will be concluded next day
- Measurements were taken. 2 replicates per variety, 6 measurements per replicate

Specific Methods & Tools Used:

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

Challenges Faced:

A batch was discarded due to cooling down of sample prior to measurements

Output(s) – Result(s):

Texture measurements raw data

DAY 3

Who: Ugo, Justice, Oluchi, Jane, Precious, Amaka

Where: Sample preparation room and Texture lab.

What:
- Texture analyser was calibrated with standard weight (2kg)
- Texture measurement parameters set
- Sample preparation was handled by same 2 assistants. Samples prepared in batch as consistently as possible.
- Only 1 contrasting variety was measured
- Data was collated and shared
- Tentative discussion with team on results
- Preparation for analyses on next food product profile to be tested (boiled yam) and collection of test yam materials

Specific Methods & Tools Used:

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

Challenges Faced:

none

Output(s) – Result(s):

Texture measurements raw data

2.3 List of material / documents distributed

- Validated SOP on sample preparation for fufu
- Draft SOP on texture measurement of fufu

2.4 General approach - methods applied

- Open discussion with lab manager, technical officer and at least 3 assistants.
- 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 three 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
- Agreement of validation exercise outcomes with prior data (see Appendix 2)

3.2 Challenges faced – paths for improvement

- It was suggested that a dedicated stable power source should be provided solely for the texture analyser to overcome occasional power outage faced at initial stage of the exercise
- Most of support staff are not skilled sufficiently in statistical analyses. A training recommended.

3.3 Feedbacks from staff trained - general remarks from support team

- Request for statistical training in cleaning textural data and statistical analyses

3.4 Next steps

- Texture Profile analyses of a wider range of fufu samples from 11 cassava varieties
- Sensory analyses and correlation with textural data

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 fufu at validation exercise

Varieties:

- 0505 – preferred elite variety
- 1368 – least preferred elite clone
- Wonono – Intermediate local variety

Statistical accuracy of texture attributes measured

	variety	cooking replicate	N	Mean	Std Err	CV
Hardness (g)	505	1	6	653.87	15.60	5.8
		2	6	812.91	43.13	13.0
	1368	1	7	1864.95	60.76	8.6
		2	6	1803.14	42.82	5.8
	wonono	1	7	668.58	15.86	6.3
		2	6	611.92	24.82	9.9
Adhesiveness (g·s)	505	1	6	-206.34	26.67	-31.7
		2	6	-145.56	21.86	-36.8
	1368	1	7	-283.70	106.20	-99.0
		2	6	-685.18	282.59	-101.0
	wonono	1	7	-43.28	8.08	-49.4
		2	6	-81.25	4.66	-14.0
Springiness (%)	505	1	6	0.326	0.014	10.2
		2	6	0.282	0.013	11.7
	1368	1	7	0.343	0.008	6.0
		2	6	0.326	0.007	5.3
	wonono	1	7	0.231	0.012	13.6
		2	6	0.259	0.006	5.5
Cohesiveness (-)	505	1	6	0.335	0.006	4.1
		2	6	0.315	0.015	11.5
	1368	1	7	0.353	0.011	8.0
		2	6	0.330	0.008	5.9
	wonono	1	7	0.259	0.012	11.9
		2	6	0.290	0.003	2.3
Gumminess (g)	505	1	6	218.73	6.03	6.8
		2	6	253.46	8.15	7.9
	1368	1	7	660.13	32.82	13.2
		2	6	595.12	20.23	8.3
	wonono	1	7	173.79	10.95	16.7
		2	6	177.64	8.16	11.2
Chewiness(g)	505	1	6	71.63	4.46	15.3
		2	6	71.55	4.53	15.5
	1368	1	7	227.13	14.96	17.4
		2	6	194.51	9.59	12.1
	wonono	1	7	40.75	4.34	28.2
		2	6	46.13	2.58	13.7
Resilience (-)	505	1	6	0.072	0.003	11.4
		2	6	0.077	0.002	5.3
	1368	1	7	0.111	0.005	11.3
		2	6	0.095	0.003	8.3
	wonono	1	7	0.084	0.004	12.2
		2	6	0.081	0.003	8.1

Outliers were not cleaned from data. Outliers can be cleaned by statistical analysis

ANOVA and Repeatability of textural parameters

Hardness

By Variety

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
variety	2	11368967	5684484	496.3815	<.0001*
Error	35	400815	11452		
C. Total	37	11769782			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
0505	12	733.38842	112.40503	32.448537	661.96967	804.80716
1368	13	1836.4202	136.14056	37.758599	1754.1512	1918.6891
wonono	13	642.43077	57.314711	15.896241	607.79584	677.0657

Connecting Letters Report

Level		Mean
1368	A	1836.4202
0505	B	733.3884
wonono	B	642.4308

Levels not connected by same letter are significantly different.

Ordered Differences Report

Level	- Level	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
1368	wonono	1193.989	41.97407	1091.27	1296.711	<.0001*
1368	0505	1103.032	42.83960	998.19	1207.872	<.0001*
0505	wonono	90.958	42.83960	-13.88	195.798	0.0997

By cooking replicate

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
cooking replicate	1	452	452	0.0014	0.9705
Error	36	11769330	326926		
C. Total	37	11769782			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
1	20	1082.8966	596.48758	133.37868	803.73177	1362.0613
2	18	1075.9884	542.82369	127.94477	806.04857	1345.9283

Connecting Letters Report

Level		Mean
1	A	1082.8966
2	A	1075.9884

Levels not connected by same letter are significantly different.

Ordered Differences Report

Level	- Level	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
1	2	6.908106	185.7655	-369.845	383.6615	0.9705

Adhesiveness

By Variety

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
variety	2	1148009.6	574005	5.8317	0.0065*
Error	35	3444973.3	98428		
C. Total	37	4592982.9			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
0505	12	-175.9489	65.200111	18.821651	-217.3751	-134.5227
1368	13	-468.9994	531.51965	147.41703	-790.1935	-147.8053
wonono	13	-60.80608	25.906976	7.1853024	-76.46151	-45.15065

Connecting Letters Report

Level			Mean
wonono	A		-60.8061
0505	A	B	-175.9489
1368		B	-468.9994

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	154375.1	154375	1.2521	0.2706
Error	36	4438607.8	123295		
C. Total	37	4592982.9			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
1	20	-176.3451	193.00735	43.157756	-266.6753	-86.01488
2	18	-303.9976	468.46576	110.41844	-536.9601	-71.03501

Connecting Letters Report

Level		Mean
1	A	-176.3451
2	A	-303.9976

Levels not connected by same letter are significantly different.

By Variety	By cooking replicate

Ordered Differences Report

Level	- Level	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
wonono	1368	408.1933	123.0558	107.042	709.3449	0.0059*
0505	1368	293.0505	125.5933	-14.311	600.4120	0.0642
wonono	0505	115.1428	125.5933	-192.219	422.5044	0.6335

Ordered Differences Report

Level	- Level	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
1	2	127.6525	114.0808	-103.716	359.0212	0.2706

Springiness

By Variety	By cooking replicate

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
variety	2	0.05565297	0.027826	31.1448	<.0001*
Error	35	0.03127092	0.000893		
C. Total	37	0.08692389			

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
cooking replicate	1	0.00087309	0.000873	0.3653	0.5494
Error	36	0.08605080	0.002390		
C. Total	37	0.08692389			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
0505	12	0.304	0.0391756	0.011309	0.279109	0.328891
1368	13	0.335	0.0202155	0.0056068	0.3227839	0.3472161
wonono	13	0.2439231	0.0281142	0.0077975	0.2269338	0.2609123

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
1	20	0.2986	0.0581354	0.0129995	0.2713918	0.3258082
2	18	0.289	0.0358395	0.0084475	0.2711774	0.3068226

Connecting Letters Report

Level		Mean
1368	A	0.33500000
0505	B	0.30400000
wonono	C	0.24392308

Levels not connected by same letter are significantly different.

Connecting Letters Report

Level		Mean
1	A	0.29860000
2	A	0.28900000

Levels not connected by same letter are significantly different.

Ordered Differences Report

Level	- Level	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
1368	wonono	0.0910769	0.0117241	0.0623848	0.1197690	<.0001*
0505	wonono	0.0600769	0.0119659	0.0307932	0.0893607	<.0001*
1368	0505	0.0310000	0.0119659	0.0017162	0.0602838	0.0361*

Ordered Differences Report

Level	- Level	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
1	2	0.0096000	0.0158843	-0.022615	0.0418150	0.5494

Cohesiveness

By Variety	By cooking replicate

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
variety	2	0.03328369	0.016642	22.4386	<.0001*
Error	35	0.02595813	0.000742		
C. Total	37	0.05924182			

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
cooking replicate	1	0.00008400	0.000084	0.0511	0.8224
Error	36	0.05915781	0.001643		
C. Total	37	0.05924182			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
0505	12	0.3248333	0.0280481	0.0080968	0.3070124	0.3426543
1368	13	0.3424615	0.0263964	0.007321	0.3265104	0.3584127
wonono	13	0.2734615	0.0272996	0.0075716	0.2569645	0.2899585

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
1	20	0.3147	0.0489759	0.0109514	0.2917786	0.3376214
2	18	0.3117222	0.0282672	0.0066626	0.2976653	0.3257792

By Variety

Connecting Letters Report

Level		Mean
1368	A	0.34246154
0505	A	0.32483333
wonono	B	0.27346154

Levels not connected by same letter are significantly different.

Ordered Differences Report

Level	- Level	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
1368	wonono	0.0690000	0.0106818	0.042859	0.0951414	<.0001*
0505	wonono	0.0513718	0.0109021	0.024691	0.0780523	0.0001*
1368	0505	0.0176282	0.0109021	-0.009052	0.0443087	0.2520

By cooking replicate

Connecting Letters Report

Level		Mean
1	A	0.31470000
2	A	0.31172222

Levels not connected by same letter are significantly different.

Ordered Differences Report

Level	- Level	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
1	2	0.0029778	0.0131703	-0.023733	0.0296886	0.8224

Gumminess

By Variety

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
variety	2	1571335.2	785668	323.7345	<.0001*
Error	35	84941.1	2427		
C. Total	37	16562763			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
0505	12	236.09792	24.680916	7.1247667	220.41641	251.77942
1368	13	630.12669	77.008138	21.358215	583.59114	676.66224
wonono	13	175.57131	24.28553	6.7355943	160.89571	190.24691

Connecting Letters Report

Level		Mean
1368	A	630.12669
0505	B	236.09792
wonono	C	175.57131

Levels not connected by same letter are significantly different.

Ordered Differences Report

Level	- Level	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
1368	wonono	454.5554	19.32272	407.2674	501.8434	<.0001*
1368	0505	394.0288	19.72117	345.7656	442.2919	<.0001*
0505	wonono	60.5266	19.72117	12.2635	108.7897	0.0112*

By cooking replicate

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
cooking replicate	1	2252.2	2252.2	0.0490	0.8260
Error	36	1654024.0	45945.1		
C. Total	37	16562763			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
1	20	357.49435	234.43482	52.421219	247.77548	467.21322
2	18	342.07567	189.39378	44.640541	247.89236	436.25898

Connecting Letters Report

Level		Mean
1	A	357.49435
2	A	342.07567

Levels not connected by same letter are significantly different.

Ordered Differences Report

Level	- Level	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
1	2	15.41868	69.64023	-125.820	156.6569	0.8260

Chewiness

By Variety

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
variety	2	211113.96	105557	206.5014	<.0001*
Error	35	17890.89	511		
C. Total	37	229004.85			

By cooking replicate

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
cooking replicate	1	1184.51	1184.51	0.1872	0.6679
Error	36	227820.35	6328.34		
C. Total	37	229004.85			

By Variety	By cooking replicate

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
0505	12	71.592167	10.499353	3.030902	64.921196	78.263137
1368	13	212.07715	36.045631	9.9972593	190.295	233.85931
wonono	13	43.230923	9.5168334	2.6394947	37.479958	48.981888

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
1	20	115.2469	88.460598	19.780391	73.846066	156.64773
2	18	104.06517	68.229749	16.081906	70.135311	137.99502

Connecting Letters Report

Level		Mean
1368	A	212.07715
0505	B	71.59217
wonono	C	43.23092

Levels not connected by same letter are significantly different.

Connecting Letters Report

Level		Mean
1	A	115.24690
2	A	104.06517

Levels not connected by same letter are significantly different.

Ordered Differences Report

Level	- Level	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
1368	wonono	168.8462	8.867992	147.1438	190.5487	<.0001*
1368	0505	140.4850	9.050857	118.3350	162.6349	<.0001*
0505	wonono	28.3612	9.050857	6.2113	50.5112	0.0095*

Ordered Differences Report

Level	- Level	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
1	2	11.18173	25.84554	-41.2359	63.59938	0.6679

Resilience

By Variety	By cooking replicate

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
variety	2	0.00584341	0.002922	29.2815	<.0001*
Error	35	0.00349230	0.000100		
C. Total	37	0.00933571			

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
cooking replicate	1	0.00032298	0.000323	1.2901	0.2635
Error	36	0.00901273	0.000250		
C. Total	37	0.00933571			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
0505	12	0.0745833	0.0066258	0.0019127	0.0703735	0.0787932
1368	13	0.1038462	0.0133532	0.0037035	0.0957769	0.1119154
wonono	13	0.0821538	0.0085132	0.0023611	0.0770094	0.0872983

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
1	20	0.08995	0.0195972	0.0043821	0.0807782	0.0991218
2	18	0.0841111	0.0100463	0.0023679	0.0791152	0.089107

Connecting Letters Report

Level		Mean
1368	A	0.10384615
wonono	B	0.08215385
0505	B	0.07458333

Levels not connected by same letter are significantly different.

Connecting Letters Report

Level		Mean
1	A	0.08995000
2	A	0.08411111

Levels not connected by same letter are significantly different.

Ordered Differences Report

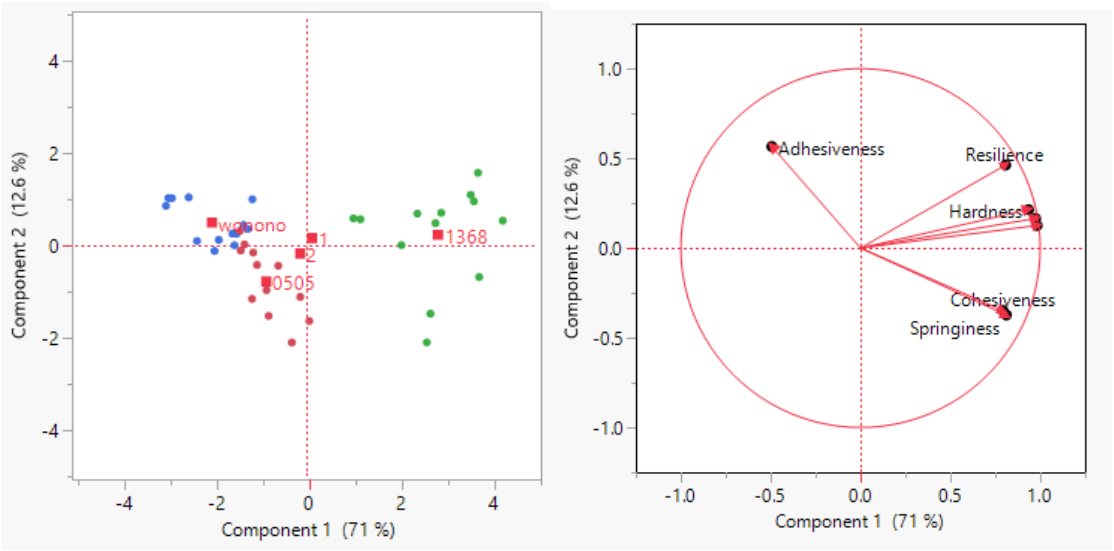
Level	- Level	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
1368	0505	0.0292628	0.0039988	0.019477	0.0390490	<.0001*
1368	wonono	0.0216923	0.0039180	0.012104	0.0312807	<.0001*
wonono	0505	0.0075705	0.0039988	-0.002216	0.0173567	0.1557

Ordered Differences Report

Level	- Level	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
1	2	0.0058389	0.0051406	-0.004587	0.0162647	0.2635

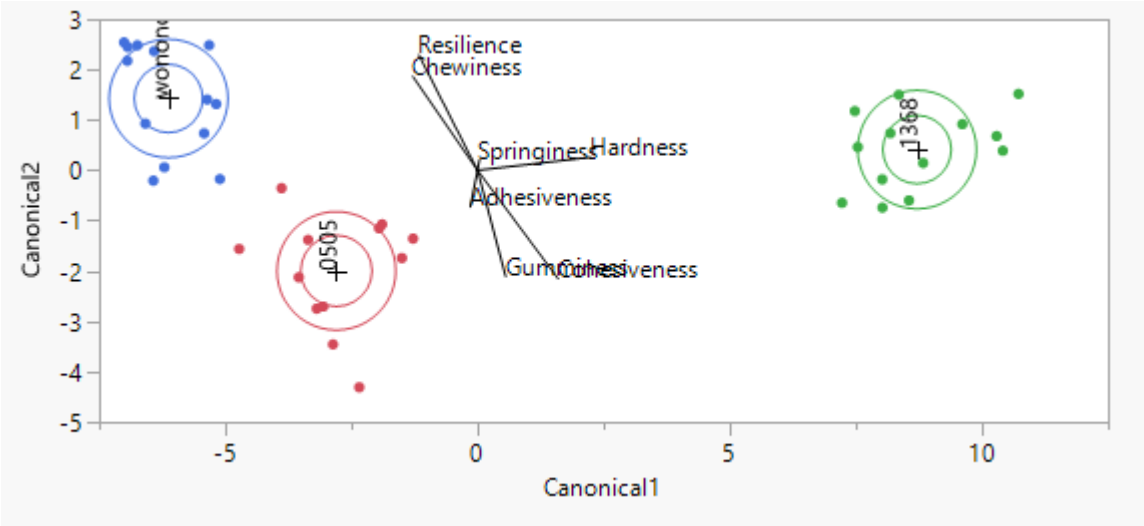
The TPA parameters for the varieties generally showed good repeatability and no significant differences between the cooking replicate means.

Discriminance between varieties based on textural profile



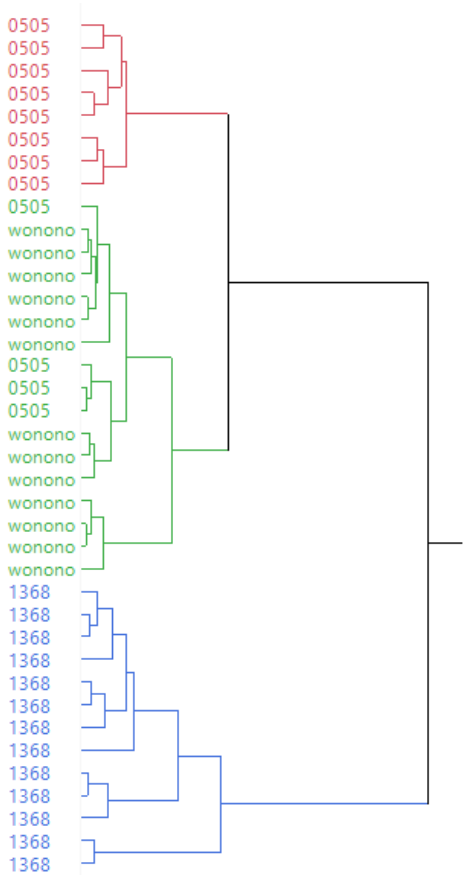
PCA

The first two components of the PCA explained 83.6 % of the variation. The PCA & discriminance analyses show that the varieties were grouped into separate components, thereby showing discriminance between the textural parameters of the varieties.



Discriminance

Discriminance analysis shows hardness is particularly positively associated with the canonical space, and therefore carry more weight in discriminating between varieties. Adhesiveness and springiness were not significant in discriminating the varieties. The more discriminating textural attributes are, therefore, cohesiveness, hardness, resilience, chewiness and gumminess.



Hierarchical classes

The varieties were clustered in three groups but with some interloping between wonono and 0505.

Summary

All TPA parameters for all the varieties generally showed good repeatability with no significant differences between the replicate means. Discriminance was good between the varieties based on ITPA.

This outcome validates previous experiment on TPA of fufu, where similar results were obtained.

Conclusion

TPA may be conducted with a texture analyser in determining discriminant character of textural attributes of fufu made from various cassava genotypes. A minimum of 6 measurements per replicate and 2 replicates per variety was sufficient to discriminate between the varieties.

4.2 Annex 2: Excerpts from prior experiments - repeatability and discriminance of texture of fufu

Varieties:

- 518 – preferred elite variety
- 1368 – least preferred elite clone
- Chenke – preferred local variety
- Wonono – Intermediate local variety

Example of ANOVA and Repeatability of Hardness attribute

By Variety

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
variety	3	10691974	3563991	333.9863	<.0001*
Error	36	384159	10671		
C. Total	39	11076132			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
0518	10	631.9367	51.066934	16.148782	595.40562	668.46778
1368	10	1990.2995	190.58114	60.267048	1853.966	2126.633
chenke	10	857.2491	39.369432	12.449707	829.08591	885.41229
wonono	10	1048.5256	46.960885	14.850336	1014.9318	1082.1194

Connecting Letters Report

Level		Mean
1368	A	1990.2995
wonono	B	1048.5256
chenke	C	857.2491
0518	D	631.9367

Levels not connected by same letter are significantly different.

Ordered Differences Report

Level	- Level	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
1368	0518	1358.363	46.19755	1233.942	1482.783	<.0001*
1368	chenke	1133.050	46.19755	1008.630	1257.471	<.0001*
1368	wonono	941.774	46.19755	817.353	1066.194	<.0001*
wonono	0518	416.589	46.19755	292.168	541.009	<.0001*
chenke	0518	225.312	46.19755	100.892	349.733	0.0001*
wonono	chenke	191.277	46.19755	66.856	315.697	0.0011*

By cooking replicate

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
cooking replicate	1	20050	20050	0.0689	0.7943
Error	38	11056082	290950		
C. Total	39	11076132			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
1	20	1154.3914	589.9035	131.90643	878.30806	1430.4747
2	20	1109.6141	483.64544	108.14641	883.26101	1335.9671

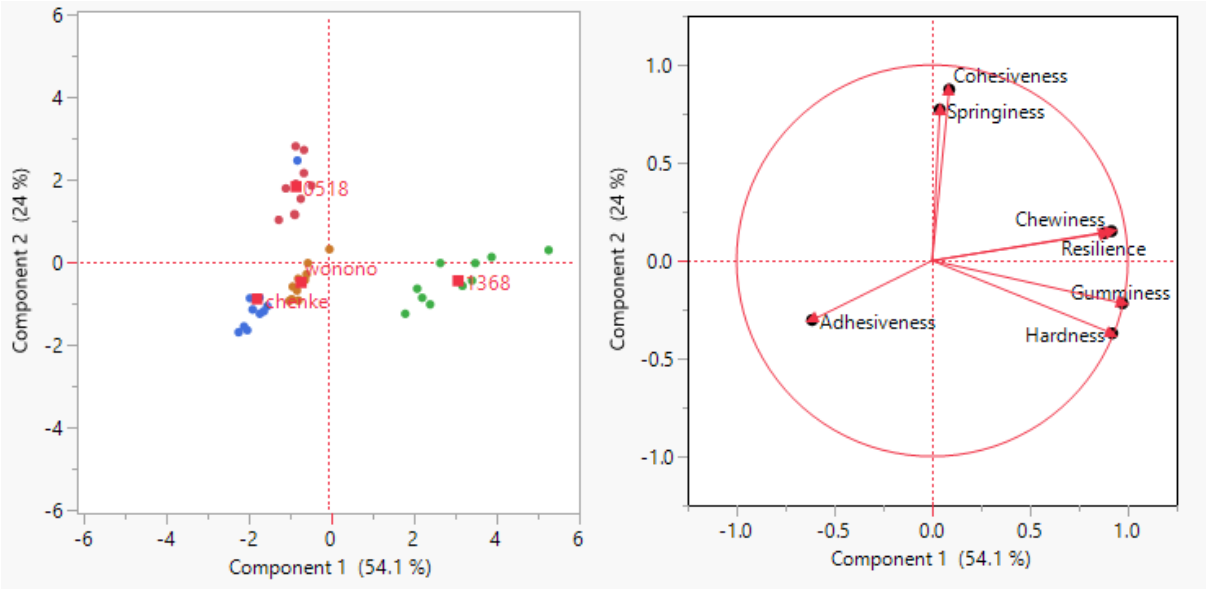
Connecting Letters Report

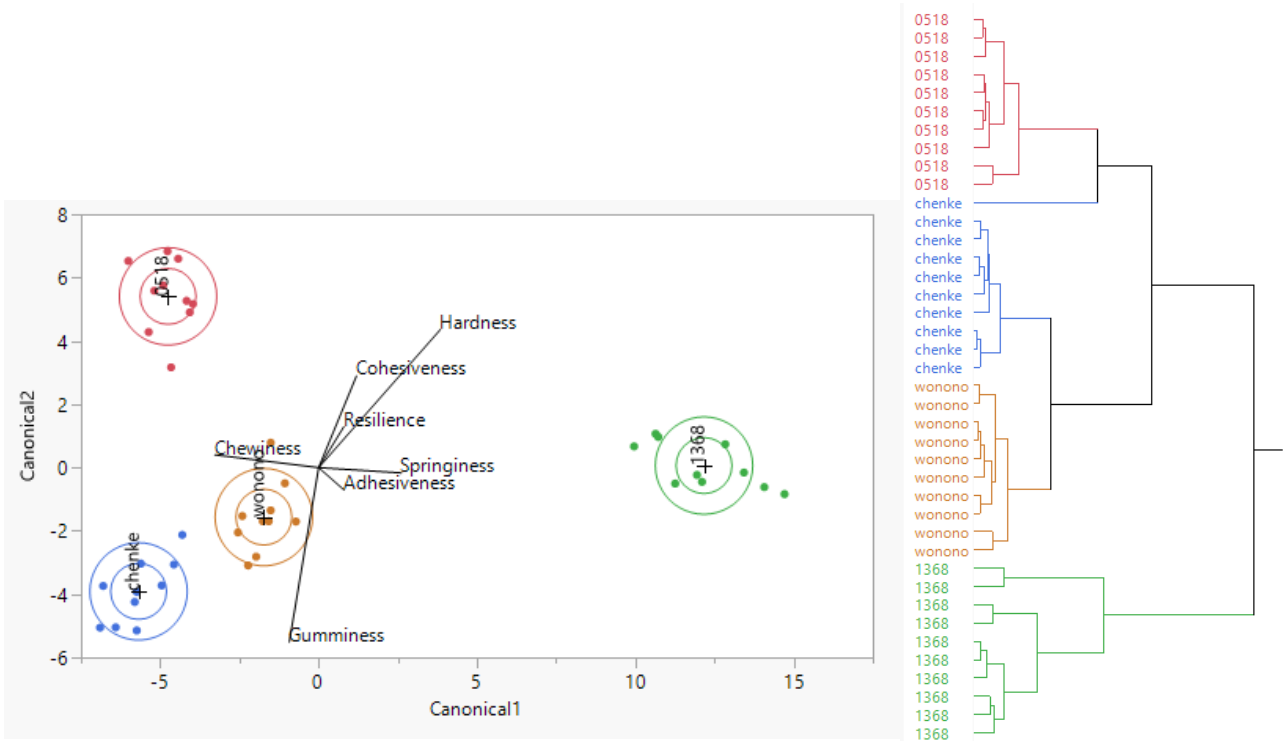
Level		Mean
1	A	1154.3914
2	A	1109.6141

Levels not connected by same letter are significantly different.

Ordered Differences Report

Level	- Level	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
1	2	44.77735	170.5724	-300.532	390.0868	0.7943





PCA, discriminant and hierarchical analyses of fufu texture from 4 contrasting cassava varieties

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