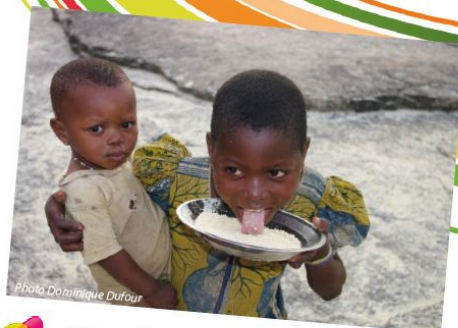


Technical & Support Mission Report for Validation of Instrumental Textural Characterization of Pounded Yam at Bowen University, Nigeria

Biophysical Characterization of Quality Traits, WP2

Iwo, 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 is aimed at establishing the veracity of the instrumental textural characterization protocol for pounded yam using a texture analyser. Instrumental texture attributes such as hardness/stiffness, adhesiveness, cohesiveness, stickiness, gumminess, chewiness and springiness were measured. A double compression mode was considered for the procedure as it simulates the action of the mastication of food.

Four freshly harvested yams with contrasting cooking and pounding qualities were used to produce pounded yam. Two sets of replicate measurements were made for a fixed cylindrical sample geometry (30 mm diameter, 36 mm height) at 45 °C, and a combination of measurement parameters (pretest speed 5 mm/s, test speed 2 mm/s, strain 50%, compression cycle interlude 5 s, compression probe 75 mm diameter, 45 mm height). 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 yam 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 Pounded yam

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

Key Words: Pounded yam, Textural attributes, PCA, Discriminant analysis, ANOVA, 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 pounded yam
- Knowledge share & transfer of SOP among partners

1.2 Specific objectives

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

1.3 Organizing committee

- Bolanle OTEGBAYO, Professor, Food Technology, Bowen University

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)
1	OTEGBAYO Bolanle	F	Professor, Head	Food Science	BOWEN, Nigeria	2	bolanle.otegbayo@bowen.edu.ng	YES
2	ORONIRAN Oluyinka	F	Nutritionist	Nutrition	BOWEN, Nigeria	2	yinkatinuke@yahoo.com	YES
3	TANIMOLA Abiola	F	Food Scientist	Food Science	BOWEN, Nigeria	2	oladeleabiola12@gmail.com	YES
4	BOLAJI Oluwatomilola	F	Assistant	Food Science	BOWEN, Nigeria	2	-	YES
5	ALAMU Ayomide	F	Assistant	Food Science	BOWEN, Nigeria	2	-	YES

1.6 Experience level of staff supported / trained

Bolanle Otegbayo is the lead food scientist at the department of Food Science. She manages the lab, and is an expert on the texture measurement procedures.

Tanimola Abiola and Oroniran Oluyinka are skilled in the use of the texture analyser

Alamu Ayomide is the primary technical officer focussed on the use of the texture analyser.

2 SUPPORT IMPLEMENTATION

2.1 Support mission agenda

6 December
<ul style="list-style-type: none">• Collection of the yam materials (4 contrasting varieties from IITA)• Arrival and familiarisation with staff, lab protocol and materials• Checking if the texture analyser is operational• Discussion on prior experimental challenges• Discussion with team and work plan breakdown• Making sure of availability of all materials for start of measurements the following day• Purchase of infra-red thermometer was ensured as team had no way of temperature measurement during texture analyses
7 December
<ul style="list-style-type: none">• Review of Draft SOP on texture for adjustments• Calibration and setting measurement parameters of texture analyser• Sample preparation of pounded yam following established SOP for pounded yam preparation• Measurements on texture analyser (1 variety, 2 replicates per variety, 13 measurements per replicate)•
8 December
<ul style="list-style-type: none">• Calibration and setting measurement parameters of texture analyser• Sample preparation of pounded yam following established SOP for pounded yam preparation• Measurements on texture analyser (2 varieties, 2 replicates per variety, 13 measurements per replicate)•
9 December
<ul style="list-style-type: none">• Calibration and setting measurement parameters of texture analyser• Sample preparation of pounded yam following established SOP for pounded yam preparation• Measurements on texture analyser (1 variety, 2 replicates per variety, 13 measurements per replicate)•
10 December
<ul style="list-style-type: none">• Data download and reposition• Tentative discussion with team on results

2.2 Daily progress of the support mission

DAY 1

Who: Otegbayo, Abiola, Ayomide, Oroniran

Where: Texture lab & kitchen

What:

- Yam materials (4 contrasting varieties) were collected from IITA, Nigeria
- Introduction to dean of faculty, staff members and assistants
- Laboratory protocol, safety introduction
- Brief review of staff competencies in texture measurements
- Checking the operationability of the texture analyser
- Allocation of work duty to team members (2 pounded yam preparation members, 1 texture measuring staff, and other auxiliary functions for the smooth running of the work).
- Draft of SOP shared
- Checking availability of other accessories / materials

Specific Methods & Tools Used:

Discussions

Challenges Faced:

- Kitchen was a bit far from lab, therefore, we had to move the pounding machine to the texture lab
- Unavailability of infra-red temperature meter for temperature monitoring during measurements

Output(s) – Result(s):

Yam materials and other materials prepared for following day. Work plan agreed on.

DAY 2

Who: Abiola, Ayomide, Oroniran

Where: Texture lab.

What:

- Texture analyser was calibrated with standard weight (2kg)
- Texture measurement parameters set (See SOP deliverables for details)
- Appropriate use of infrared thermometer ensured
- Sample preparation was handled consistently by 2 persons following the pounded yam 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, 12 measurements per replicate

Specific Methods & Tools Used:

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

Challenges Faced:

Slight delay to start due to late arrival of texture personnel

Output(s) – Result(s):

Texture measurements raw data for 1 variety completed

DAY 3

Who: Abiola, Ayomide, Oroniran

Where: Texture lab.

What:

- Texture analyser was calibrated with standard weight (2kg).
- Texture measurement parameters were set.
- Sample preparation was handled consistently by 2 persons following the pounded yam 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, 12 measurements per replicate

Specific Methods & Tools Used:

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

Challenges Faced:

none

Output(s) – Result(s):

Texture measurements raw data for 2 varieties completed

DAY 4

Who: Abiola, Ayomide, Oroniran

Where: Texture lab.

What:

- Texture analyser was calibrated with standard weight (2kg)
- Texture measurement parameters were set
- Sample preparation was handled consistently by 2 persons following the pounded yam 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, 12 measurements per replicate

Specific Methods & Tools Used:

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

Challenges Faced:

none

Output(s) – Result(s):

Texture measurements raw data for 1 variety completed

DAY 5

Who: Abiola, Ayomide, Oroniran

Where: Texture lab.

What:

- Data downloaded and stored
- Tentative discussion with team on results
- Brief statistical tutorial on cleaning textural data for outliers

Specific Methods & Tools Used:

- Statistical analyses
- Office documents (Excel)

Challenges Faced:

Statistical PCA & discriminant analyses not fully understood by 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 pounded yam
- Draft SOP on texture measurement of pounded yam

2.4 General approach - methods applied

- Open discussion with lab manager, technical officer and 2 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 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

- It was suggested that open-ended sample moulds be used rather than filling pounded yam samples into sample cups before measurements. However, some difficulty to cut sample by open-ended mould was encountered due to the highly cohesive nature of pounded yam.
- Most of support staff are not skilled sufficiently in statistical analyses. A training may be recommended.
- Inability to determine a priority quality trait (PQT) 'Stretchability' of pounded yam by the protocol.

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 yam tubers be sent to CIRAD France for development of a protocol to determine the PQT.

3.4 Next steps

- Texture Profile analyses of a wider range of pounded yam samples from more yam varieties

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 pounded yam at validation exercise

Varieties:

- TDr1401220 – intermediate elite variety
- TDr1401593 – poor elite clone
- TDr1400158 – good elite clone
- Meccakusa - landrace

Procedure:

Texture measurements using the texture analyser (TPA compression method) was carried out by preparing pounded yam based on the SOP for pounded yam preparation (RTBfoods_E.6.6_SOP) which was used with no modifications. Two preparations or cooking replicates per variety was considered. About 13 measurements per cooking replicate were collected. Measurements were made at temperature of 45°C.

Results:

Statistical descriptive of textural attributes of pounded yam

	Variety	Cooking replicate	N	Mean	Std Err	CV
Adhesiveness	TDr 1400158	1	14	-678.14	41.44	-22.87
		2	10	-1410.30	65.83	-14.76
	TDr 1401220	1	13	-849.54	74.13	-31.46
		2	16	-503.88	50.46	-40.06
	TDr 1401593	1	15	-354.07	30.40	-33.25
		2	14	-339.14	37.45	-41.32
Stickiness	TDr meccakusa	1	14	-892.64	67.47	-28.28
		2	13	-974.85	98.08	-36.28
	TDr 1400158	1	14	-135.71	4.37	-12.05
		2	10	-128.80	4.60	-11.29
	TDr 1401220	1	13	-128.62	5.85	-16.39
		2	16	-126.75	4.76	-15.01
Stiffness/Hardness	TDr 1401593	1	15	-173.20	8.64	-19.32
		2	14	-165.21	9.41	-21.32
	TDr meccakusa	1	14	-112.86	3.48	-11.53
		2	13	-122.69	7.10	-20.86
	TDr 1400158	1	14	983.29	32.18	12.25
		2	10	654.10	37.74	18.25
Chewiness	TDr 1401220	1	13	685.23	28.93	15.22
		2	16	781.56	29.47	15.08
	TDr 1401593	1	15	1136.07	40.82	13.92
		2	14	1103.64	29.31	9.94
	TDr meccakusa	1	14	625.21	34.30	20.53
		2	13	588.08	39.35	24.13
Gumminess	TDr 1400158	1	14	145.10	6.69	17.25
		2	10	367.63	35.21	30.28
	TDr 1401220	1	13	157.14	21.84	50.11
		2	16	79.94	6.89	34.47
	TDr 1401593	1	15	53.50	3.22	23.29
		2	14	45.89	2.87	23.42
	TDr meccakusa	1	14	178.67	16.73	35.04
		2	13	178.04	23.35	47.28
Gumminess	TDr 1400158	1	14	339.07	8.58	9.47

	Variety	Cooking replicate	N	Mean	Std Err	CV
		2	10	465.10	20.41	13.88
	TDr 1401220	1	13	298.77	16.77	20.23
		2	16	229.88	7.05	12.27
	TDr 1401593	1	15	231.87	7.35	12.27
		2	14	209.50	7.75	13.84
	TDr meccakusa	1	14	313.57	11.31	13.50
		2	13	305.15	20.84	24.62
Cohesiveness	TDr 1400158	1	14	0.35	0.01	14.15
		2	10	0.73	0.05	21.74
	TDr 1401220	1	13	0.45	0.04	30.69
		2	16	0.30	0.02	27.70
	TDr 1401593	1	15	0.21	0.01	13.50
		2	14	0.19	0.01	11.04
	TDr meccakusa	1	14	0.53	0.04	27.68
		2	13	0.54	0.04	29.45
Springiness	TDr 1400158	1	14	0.43	0.01	11.08
		2	10	0.78	0.05	20.98
	TDr 1401220	1	13	0.50	0.04	26.81
		2	16	0.34	0.02	23.54
	TDr 1401593	1	15	0.23	0.01	12.86
		2	14	0.22	0.01	13.93
	TDr meccakusa	1	14	0.56	0.03	23.21
		2	13	0.56	0.05	29.03

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

Adhesiveness

By Variety

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
variety	3	7022211	2340737	27.3669	<.0001*
Error	105	8980810	85532		
C. Total	108	16003021			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
TDr1400158	24	-983.2083	408.0504	83.292939	-1155.513	-810.9038
TDr1401220	29	-658.8276	288.18261	53.514168	-768.4464	-549.2088
TDr1401593	29	-346.8621	126.90568	23.565793	-395.1344	-298.5897
TDr meccakusa	27	-932.2222	302.22716	58.163644	-1051.779	-812.6651

Connecting Letters Report

Level		Mean
TDr1401593	A	-346.8621
TDr1401220	B	-658.8276
TDr meccakusa	C	-932.2222
TDr1400158	C	-983.2083

Levels not connected by same letter are significantly different.

Ordered Differences Report

Level	- Level	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
TDr1401593	TDr1400158	636.3463	80.70425	425.655	847.0375	<.0001*
TDr1401593	TDr meccakusa	585.3602	78.21251	381.174	789.5463	<.0001*
TDr1401220	TDr1400158	324.3807	80.70425	113.690	535.0720	0.0006*
TDr1401593	TDr1401220	311.9655	76.80316	111.459	512.4723	0.0005*
TDr1401220	TDr meccakusa	273.3946	78.21251	69.208	477.5808	0.0038*
TDr meccakusa	TDr1400158	50.9861	82.04662	-163.210	265.1818	0.9250

By cooking replicate

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
cooking replicate	1	105196	105196	0.7080	0.4020
Error	107	15897825	148578		
C. Total	108	16003021			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
1	56	-684.75	295.15754	39.442085	-763.7937	-605.7063
2	53	-746.9057	462.15084	63.481299	-874.2902	-619.5211

Connecting Letters Report

Level		Mean
1	A	-684.7500
2	A	-746.9057

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	62.15566	73.86833	-84.2797	208.5910	0.4020

Stickiness

By Variety						By cooking replicate							
Analysis of Variance						Analysis of Variance							
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F	Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F		
variety	3	43480.14	14493.4	25.6104	<.0001*	cooking replicate	1	119.05	119.051	0.1239	0.7255		
Error	105	59421.44	565.9			Error	107	102782.53	960.584				
C. Total	108	102901.58				C. Total	108	102901.58					
Means and Std Deviations						Means and Std Deviations							
Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%	Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
TDr1400158	24	-132.8333	15.686235	3.2019393	-139.457	-126.2096	1	56	-138.3929	31.717319	4.238405	-146.8868	-129.8989
TDr1401220	29	-127.5862	19.629637	3.6451321	-135.0529	-120.1195	2	53	-136.3019	30.208624	4.1494736	-144.6284	-127.9754
TDr1401593	29	-169.3448	33.944572	6.3033488	-182.2567	-156.433							
TDr meccakusa	27	-117.5926	20.296379	3.9060401	-125.6216	-109.5636							
Connecting Letters Report						Connecting Letters Report							
Level		Mean					Level		Mean				
TDr meccakusa	A	-117.5926					2	A	-136.3019				
TDr1401220	A	-127.5862					1	A	-138.3929				
TDr1400158	A	-132.8333											
TDr1401593	B	-169.3448											
Levels not connected by same letter are significantly different.						Levels not connected by same letter are significantly different.							
Ordered Differences Report						Ordered Differences Report							
Level	- Level	Difference	Std Err Dif	Lower CL	Upper CL	p-Value	Level	- Level	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
TDr meccakusa	TDr1401593	51.75223	6.361947	35.1434	68.36111	<.0001*	2	1	2.090970	5.939489	-9.68337	13.86532	0.7255
TDr1401220	TDr1401593	41.75862	6.247308	25.4490	58.06821	<.0001*							
TDr1400158	TDr1401593	36.51149	6.564630	19.3735	53.64950	<.0001*							
TDr meccakusa	TDr1400158	15.24074	6.673820	-2.1823	32.66381	0.1084							
TDr meccakusa	TDr1401220	9.99361	6.361947	-6.6153	26.60248	0.3997							
TDr1401220	TDr1400158	5.24713	6.564630	-11.8909	22.38513	0.8546							

Stiffness/Hardness

By Variety							By cooking replicate						
Analysis of Variance							Analysis of Variance						
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F		Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F	
variety	3	4034033.7	1344678	60.5096	<.0001*		cooking replicate	1	134830.1	134830	2.3147	0.1311	
Error	105	2333366.5	22223				Error	107	6232570.1	58248			
C. Total	108	6367400.2					C. Total	108	6367400.2				
Means and Std Deviations							Means and Std Deviations						
Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%	Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
TDr1400158	24	846.125	203.11109	41.459877	760.35871	931.89129	1	56	865.5	248.86543	33.256041	798.8534	932.1466
TDr1401220	29	738.37931	120.34932	22.348307	692.60088	784.15774	2	53	795.13208	233.13087	32.022987	730.87325	859.3909
TDr1401593	29	1120.4138	135.47971	25.15795	1068.8801	1171.9475							
TDr meccakusa	27	607.33333	133.73884	25.738051	554.42801	660.23866							
Connecting Letters Report							Connecting Letters Report						
Level				Mean			Level			Mean			
TDr1401593	A			1120.4138			1	A		865.50000			
TDr1400158	B			846.1250			2	A		795.13208			
TDr1401220	C			738.3793									
TDr meccakusa	D			607.3333									
Levels not connected by same letter are significantly different.							Levels not connected by same letter are significantly different.						

By Variety							By cooking replicate						
Ordered Differences Report							Ordered Differences Report						
Level	- Level	Difference	Std Err Dif	Lower CL	Upper CL	p-Value	Level	- Level	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
TDr1401593	TDr meccakusa	513.0805	39.86667	409.0022	617.1587	<.0001*	1	2	70.36792	46.25120	-21.3197	162.0555	0.1311
TDr1401593	TDr1401220	382.0345	39.14829	279.8317	484.2373	<.0001*							
TDr1401593	TDr1400158	274.2888	41.13677	166.8948	381.6828	<.0001*							
TDr1400158	TDr meccakusa	238.7917	41.82100	129.6113	347.9720	<.0001*							
TDr1401220	TDr meccakusa	131.0460	39.86667	26.9677	235.1242	0.0074*							
TDr1400158	TDr1401220	107.7457	41.13677	0.3517	215.1397	0.0489*							

Chewiness

By Variety

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
variety	3	524002.2	174667	27.0834	<.0001*
Error	105	677169.6	6449		
C. Total	108	1201171.8			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
TDr1400158	24	237.82216	133.2795	27.205564	181.54317	294.10116
TDr1401220	29	114.5476	67.751254	12.581092	88.776399	140.3188
TDr1401593	29	49.823595	12.09248	2.2455172	45.223861	54.423328
TDr meccakusa	27	178.36556	72.32138	13.918256	149.75618	206.97495

Connecting Letters Report

Level		Mean
TDr1400158	A	237.82216
TDr meccakusa	B	178.36556
TDr1401220	C	114.54760
TDr1401593	D	49.82359

Levels not connected by same letter are significantly different.

Ordered Differences Report

Level	- Level	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
TDr1400158	TDr1401593	187.9986	22.16090	130.1440	245.8531	<.0001*
TDr meccakusa	TDr1401593	128.5420	21.47668	72.4737	184.6103	<.0001*
TDr1400158	TDr1401220	123.2746	22.16090	65.4200	181.1291	<.0001*
TDr1401220	TDr1401593	64.7240	21.08968	9.6660	119.7820	0.0143*
TDr meccakusa	TDr1401220	63.8180	21.47668	7.7497	119.8862	0.0190*
TDr1400158	TDr meccakusa	59.4566	22.52951	0.6398	118.2734	0.0465*

By cooking replicate

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
cooking replicate	1	8376.9	8376.9	0.7515	0.3880
Error	107	1192794.9	11147.6		
C. Total	108	1201171.8			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
1	56	131.7501	69.96214	9.3490842	113.01412	150.48609
2	53	149.28983	133.27143	18.306239	112.55567	186.02399

Connecting Letters Report

Level		Mean
2	A	149.28983
1	A	131.75010

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	17.53972	20.23356	-22.5710	57.65040	0.3880

Gumminess

By Variety							By cooking replicate						
Analysis of Variance							Analysis of Variance						
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F		Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F	
variety	3	420408.51	140136	41.9527	<.0001*		cooking replicate	1	1445.25	1445.25	0.2009	0.6549	
Error	105	350735.75	3340				Error	107	769699.01	7193.45			
C. Total	108	771144.26					C. Total	108	771144.26				
Means and Std Deviations							Means and Std Deviations						
Level	Number	Mean	Std Dev	Std Err	Lower 95%	Upper 95%	Level	Number	Mean	Std Dev	Std Err	Lower 95%	Upper 95%
TDr1400158	24	391.58333	78.997477	16.125293	358.22562	424.94104	1	56	294.625	57.815557	7.7259288	279.14189	310.10811
TDr1401220	29	260.75862	56.639622	10.517714	239.21406	282.30318	2	53	287.33962	106.1434	14.579917	258.08288	316.59637
TDr1401593	29	221.06897	30.405511	5.6461616	209.50333	232.6346							
TDr meccakusa	27	309.51852	59.320103	11.416159	286.05227	332.98477							

By Variety

Connecting Letters Report

Level		Mean
TDr1400158	A	391.58333
TDr meccakusa	B	309.51852
TDr1401220	C	260.75862
TDr1401593	D	221.06897

Levels not connected by same letter are significantly different.

Ordered Differences Report

Level	- Level	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
TDr1400158	TDr1401593	170.5144	15.94882	128.8774	212.1513	<.0001*
TDr1400158	TDr1401220	130.8247	15.94882	89.1878	172.4616	<.0001*
TDr meccakusa	TDr1401593	88.4496	15.45641	48.0982	128.8009	<.0001*
TDr1400158	TDr meccakusa	82.0648	16.21410	39.7353	124.3943	<.0001*
TDr meccakusa	TDr1401220	48.7599	15.45641	8.4085	89.1113	0.0111*
TDr1401220	TDr1401593	39.6897	15.17789	0.0654	79.3139	0.0495*

By cooking replicate

Connecting Letters Report

Level		Mean
1	A	294.62500
2	A	287.33962

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	7.285377	16.25361	-24.9355	39.50627	0.6549

Cohesiveness

By Variety

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
variety	3	1.9636944	0.654565	31.3202	<.0001*
Error	105	2.1944115	0.020899		
C. Total	108	4.1581060			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
TDr1400158	24	0.5078387	0.219695	0.0448451	0.4150696	0.6006077
TDr1401220	29	0.3691741	0.1313578	0.0243925	0.3192083	0.41914
TDr1401593	29	0.1983866	0.0257041	0.0047731	0.1886093	0.2081639
TDr meccakusa	27	0.5334735	0.1496997	0.0288097	0.4742542	0.5926927

Connecting Letters Report

Level		Mean
TDr meccakusa	A	0.53347347
TDr1400158	A	0.50783868
TDr1401220	B	0.36917414
TDr1401593	C	0.19838658

Levels not connected by same letter are significantly different.

Ordered Differences Report

Level	- Level	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
TDr meccakusa	TDr1401593	0.3350869	0.0386614	0.234155	0.4360186	<.0001*
TDr1400158	TDr1401593	0.3094521	0.0398931	0.205305	0.4135993	<.0001*
TDr1401220	TDr1401593	0.1707876	0.0379647	0.071675	0.2699005	0.0001*
TDr meccakusa	TDr1401220	0.1642993	0.0386614	0.063368	0.2652310	0.0003*
TDr1400158	TDr1401220	0.1386645	0.0398931	0.034517	0.2428118	0.0041*
TDr meccakusa	TDr1400158	0.0256348	0.0405566	-0.080245	0.1315143	0.9215

By cooking replicate

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
cooking replicate	1	0.0333314	0.033331	0.8646	0.3545
Error	107	4.1247746	0.038549		
C. Total	108	4.1581060			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
1	56	0.3779528	0.1577784	0.021084	0.3356995	0.4202061
2	53	0.4129399	0.2302007	0.0316205	0.3494887	0.4763911

Connecting Letters Report

Level		Mean
2	A	0.41293992
1	A	0.37795281

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	0.0349871	0.0376261	-0.039602	0.1095765	0.3545

Springiness

By Variety						By cooking replicate					
Analysis of Variance						Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F	Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
variety	3	2.1886987	0.729566	37.2568	<.0001*	cooking replicate	1	0.0119981	0.011998	0.3033	0.5830
Error	105	2.0561207	0.019582			Error	107	4.2328213	0.039559		
C. Total	108	4.2448194				C. Total	108	4.2448194			

By Variety

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
TDr1400158	24	0.5725394	0.2071419	0.0422827	0.485071	0.6600078
TDr1401220	29	0.4141124	0.1346537	0.0250046	0.3628929	0.4653319
TDr1401593	29	0.2228203	0.0297648	0.0055272	0.2114984	0.2341423
TDr meccakusa	27	0.5592086	0.143681	0.0276514	0.5023703	0.6160469

Connecting Letters Report

Level		Mean
TDr1400158	A	0.57253940
TDr meccakusa	A	0.55920861
TDr1401220	B	0.41411237
TDr1401593	C	0.22282034

Levels not connected by same letter are significantly different.

By cooking replicate

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
1	56	0.4238357	0.1585183	0.0211829	0.3813842	0.4662872
2	53	0.4448269	0.2341424	0.0321619	0.3802893	0.5093645

Connecting Letters Report

Level		Mean
2	A	0.44482691
1	A	0.42383572

Levels not connected by same letter are significantly different.

Ordered Differences Report

Level	- Level	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
TDr1400158	TDr1401593	0.3497191	0.0386156	0.248907	0.4505312	<.0001*
TDr meccakusa	TDr1401593	0.3363883	0.0374234	0.238689	0.4340879	<.0001*
TDr1401220	TDr1401593	0.1912920	0.0367490	0.095353	0.2872311	<.0001*
TDr1400158	TDr1401220	0.1584270	0.0386156	0.057615	0.2592392	0.0005*
TDr meccakusa	TDr1401220	0.1450962	0.0374234	0.047397	0.2427958	0.0010*
TDr1400158	TDr meccakusa	0.0133308	0.0392579	-0.089158	0.1158198	0.9864

Ordered Differences Report

Level	- Level	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
2	1	0.0209912	0.0381157	-0.054569	0.0965512	0.5830

The TPA parameters for the varieties showed good repeatability with no significant differences between the replicate means. Generally, ANOVA reveals all the varieties were significantly different from one another for all the textural attributes.

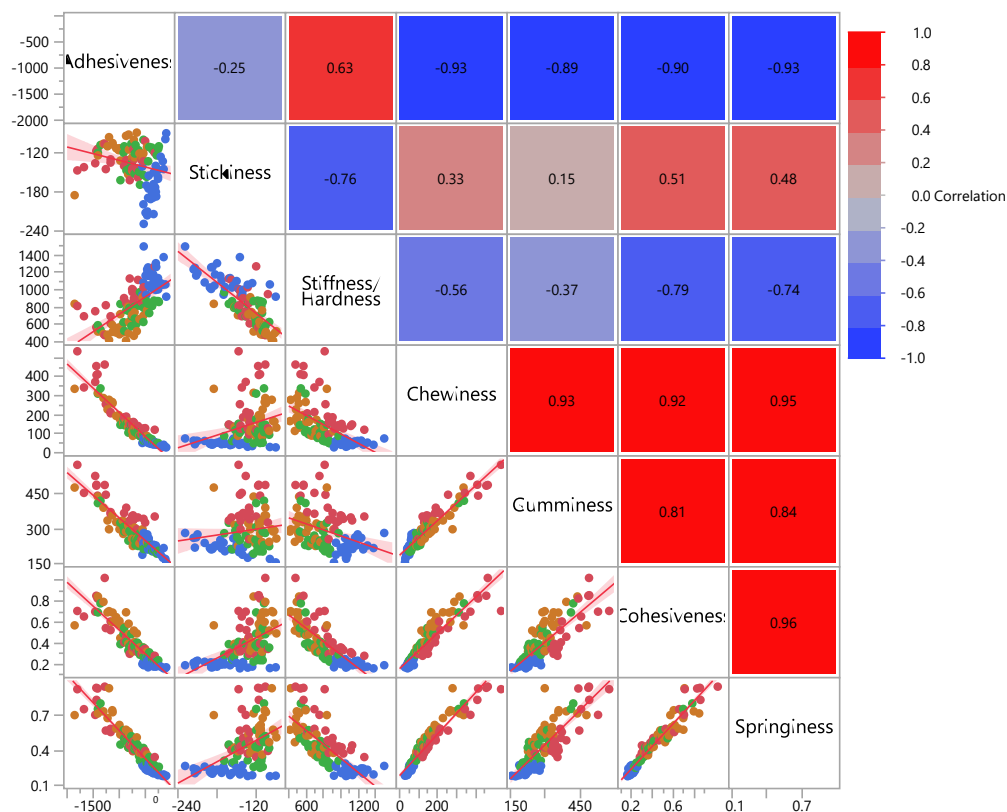
Correlations between instrumental textural attributes

Considering correlations between the textural attributes based on individual measurements of cooking replicate values, the results below were obtained, showing significant correlations between all the attribute pairs except between gumminess and stickiness.

Higher correlations were found between the following pairs of attributes:

- Chewiness & Adhesiveness ($r = -0.93$)
- Chewiness & Gumminess ($r = 0.93$)
- Gumminess & Adhesiveness ($r = -0.89$)
- Adhesiveness & Cohesiveness ($r = -0.90$)
- Chewiness & Cohesiveness ($r = 0.92$)
- Gumminess & Cohesiveness ($r = 0.81$)
- Adhesiveness & Springiness ($r = -0.93$)
- Chewiness & Springiness ($r = 0.95$)
- Gumminess & Springiness ($r = 0.84$)
- Cohesiveness & Springiness ($r = 0.96$)

Scatterplot Matrix

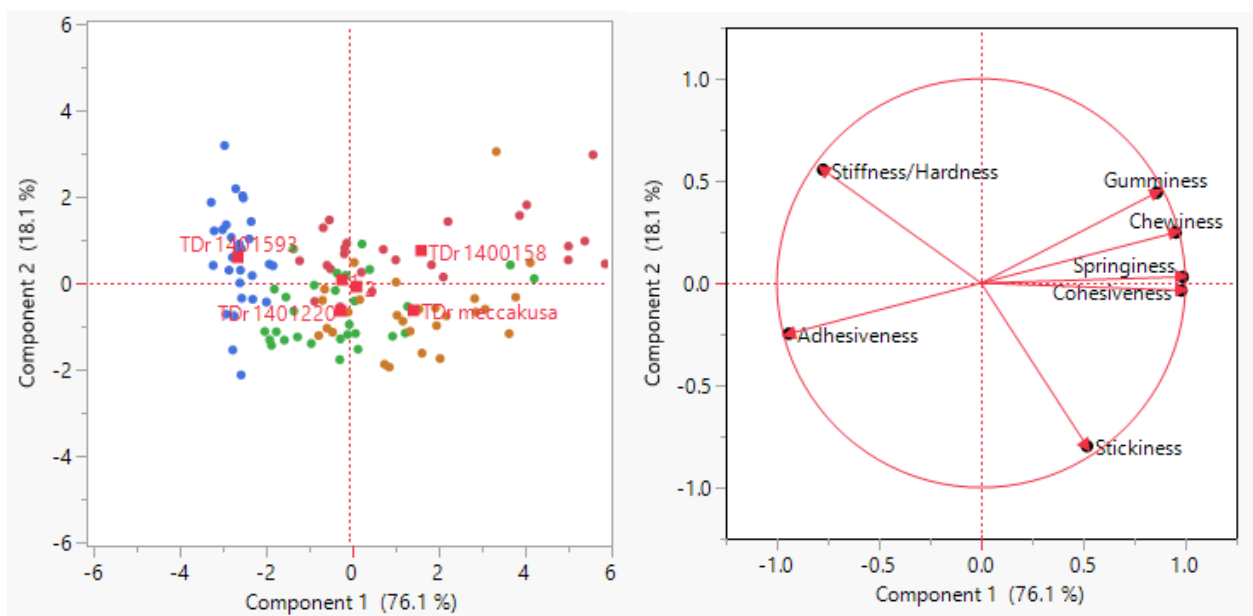


Correlation Probability

	Adhesiveness	Stickiness	Stiffness/Hardness	Chewiness	Gumminess	Cohesiveness	Springiness
Adhesiveness	<.0001						
Stickiness	0.0075	<.0001					
Stiffness/Hardness	<.0001	<.0001	<.0001				
Chewiness	<.0001	0.0005	<.0001	<.0001			
Gumminess	<.0001	0.1079	<.0001	<.0001	<.0001		
Cohesiveness	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	
Springiness	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001

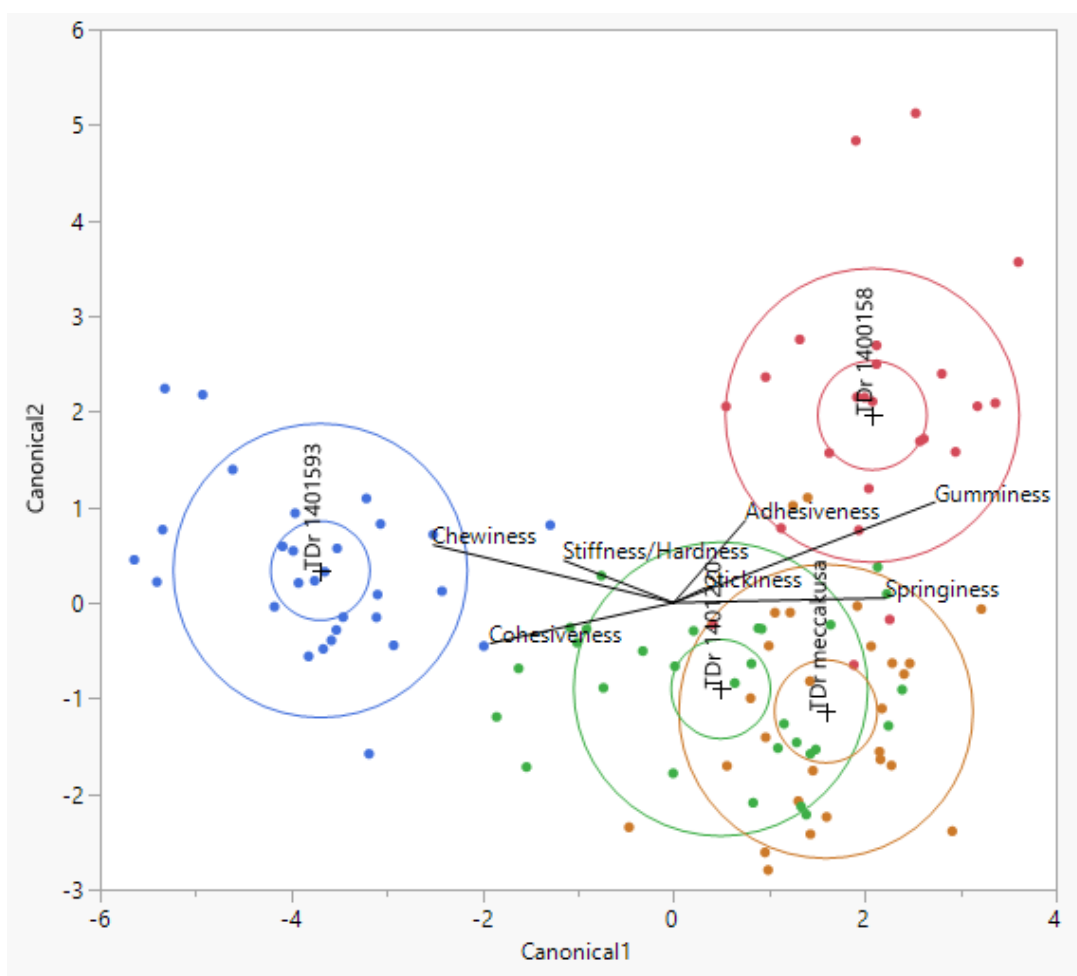
Discriminance between varieties based on textural profile

Variable	N	Mean	Std Err	CV	P-value
Adhesiveness	109	-714.97	36.87	-53.84	<0.0001
Stickiness	109	-137.38	2.96	-22.47	<0.0001
Stiffness/Hardness	109	831.28	23.26	29.21	<0.0001
Chewiness	109	140.28	10.10	75.18	<0.0001
Gumminess	109	291.08	8.09	29.03	<0.0001
Cohesiveness	109	0.39	0.02	49.68	<0.0001
Springiness	109	0.43	0.02	45.68	<0.0001



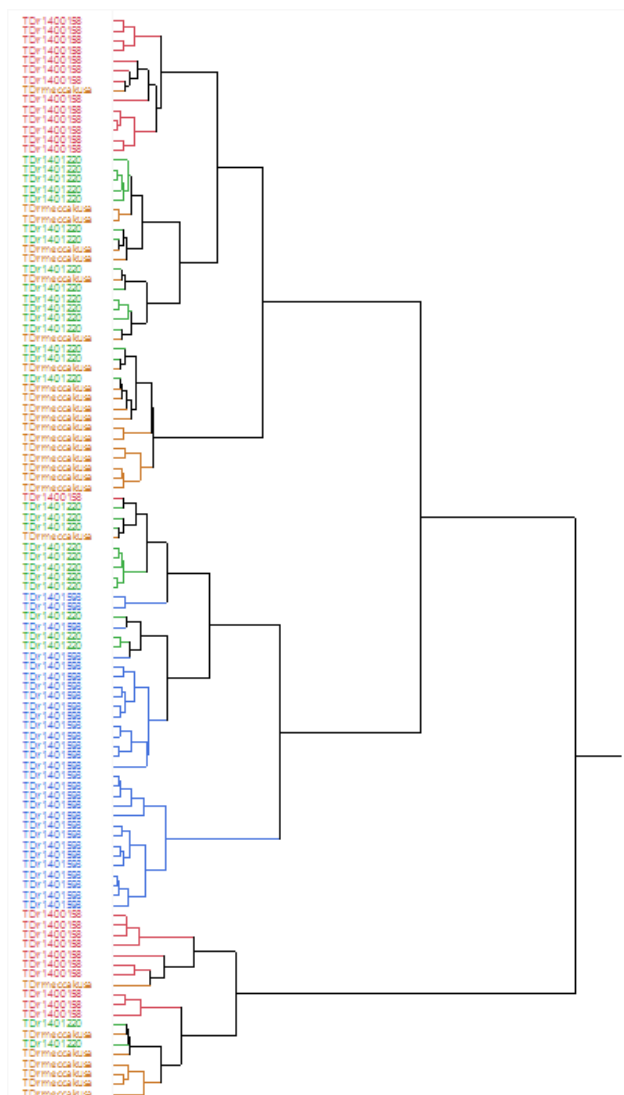
PCA

The first two components of the score plot of the PCA explained 94.2 % of the variation. The PCA shows that the varieties were grouped separately between the components, thereby showing differences between the textural attributes of the varieties. However, an overlap occurs between Meccakusa and TDr 1401220. The textural quality attributes that contribute the most to variation among the varieties are chewiness, gumminess, springiness, cohesiveness, and stiffness/hardness.



Discriminance

The first 2 canonicals explain 97 % of the variations. Discriminance analysis shows gumminess and springiness are particularly associated with the positive canonical domain, and carry more weight in discriminating between varieties. Chewiness and cohesiveness, on the other hand, are associated with the negative canonical domain, and carry more weights in discriminating between varieties. Stiffness/hardness and adhesiveness also have good discriminating power, while stickiness was poorly discriminating between the varieties.



Hierarchical classes

The varieties were classified into separate groups within the hierarchical pattern, but there were some interlopes between Meccakusa and TDr 1401220.

Conclusion

TPA may be conducted with a texture analyser in determining discriminant character of textural attributes of pounded yam made from various yam genotypes. Particularly, the hardness, cohesiveness, gumminess, and chewiness are most discriminatory. Cooking replication did not have a significant effect on the textural attributes. A minimum of 2 cooking replicates and about 13 measurements per replicate was sufficient to show discrimination between the varieties.



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