

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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https://rtbfoods.cirad.fr

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<u>Ethics</u>: 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	М	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@bo wen.edu.ng	YES
2	ORONIRAN Oluyinka	F	Nutritionist	Nutrition	BOWEN, Nigeria	2	yinkatinuke@yahoo.c om	YES
3	TANIMOLA Abiola	F	Food Scientist	Food Science	BOWEN, Nigeria	2	oladeleabiola12@gma il.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

- Collection of the yam materials (4 contrasting varieties from IITA)
- Arrival and familiarisation with staff, lab protocol and materials
- Checking if the texture analyser ifsoperational
- 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

- 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

- 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

- 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)

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10 December

- 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	Ν	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
	TDr meccakusa	1	14	-892.64	67.47	-28.28
		2	13	-974.85	98.08	-36.28
Stickiness	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
	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
Stiffness/Hardness	TDr 1400158	1	14	983.29	32.18	12.25
		2	10	654.10	37.74	18.25
	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
Chewiness	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	Ν	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 Vari	ety						By co	oking	g replic	ate			
Analysis	of Var	ance					Analy	sis of Va	riance				
Source	DF	Sum of Squares	Mean Squ	are FRat	io Prob>l	F	Source		DF	Sum of Squares	Mean Square	F Ratio	Prob > F
variety	3	7022211	2340	737 27.36	69 <.0001 [*]		cooking	g replicate	1	105196	105196	0.7080	0.4020
Error	105	8980810	85	532			Error		107	15897825	148578		
C. Total	108	16003021					C. Total		108	16003021			
Means an	d Std D	eviations					Mear	s and St	d Deviati	ons			
				Std Err							Std Err		
Level	Num	ber Me	an Std Dev	/ Mean	Lower 95%	Upper 95%	Level	Number	Mean	Std Dev	v Mean	Lower 95%	Upper 95%
TDr 1400158	В	24 -983.20	083 408.0504	4 83.292939	-1155.513	-810.9038	1	56	-684.75	295,1575	4 39,442085	-763,7937	-605.7063
TDr 1401220	D	29 -658.82	276 288.18261	53.514168	-768.4464	-549.2088	2	52	-746 9057	462 1509	1 63 / 81200	-874 2002	-610 5211
TDr 1401593	3	29 -346.8	521 126.90568	3 23.565793	-395.1344	-298.5897	2		-740.5057	402.1500	4 05.401255	-014.2302	-015.5211
Connecti	ng Lette	ers Repor	t				Con	necting	Letters	Report			
Level		Me	an				Level		Mean	-			
TDr 140159	3 A	-346.86	521				1		04 7500				
TDr 140122	0 В	-658.82	76					A -0	84.7500				
TDr meccak	usa	C -932.22	22				2	A -7	46.9057				
1Dr 140015	8	L -983.2L					Levels	not conn	nected by s	ame letter	are significa	antly differe	ent.
Levels not co	onnected	by same lette	er are significai	ntly different.					-		_	-	
Ordered I	Differen	ces Repo	rt				Orde	red Diff	ferences	Report			
	- Leve	el D	ifference St	d Err Dif Lo	wer CL Upp	per CL p-Va	level	- Level	Differenc	e Std Frr	Dif Lower	CI Uppe	r CL p-Valu
Level		00150	636.3463 8	30.70425	425.655 84	7.0375 <.00	1	2	62 1556	6 72.04	022 04 2	707 200	5010 0 4020
Level TDr 140159	3 TDr 14	00136				0 6462 200		2	02.1330	0 /5.80	-04.2	208.2	0.4020
Level TDr 140159 TDr 140159	3 TDr14 3 TDrm	eccakusa	585.3602	78.21251	381.174 78	9.5465 <.00							
Level TDr 140159 TDr 140159 TDr 140122	3 TDr 14 3 TDr m 0 TDr 14	eccakusa 100158	585.3602 7 324.3807 8	78.21251 30.70425	381.174 78 113.690 53	9.5463 <.00 5.0720 0.00							
Level TDr 140159 TDr 140159 TDr 140122 TDr 140122 TDr 140159	3 TDr 14 3 TDr m 0 TDr 14 3 TDr 14	eccakusa 100158 101220	585.3602 7 324.3807 8 311.9655 7	78.21251 30.70425 76.80316	381.174 78 113.690 53 111.459 51	5.0720 0.00 2.4723 0.00							
Level TDr 140159 TDr 140159 TDr 140122 TDr 140122 TDr 140122	3 TDr 14 3 TDr m 0 TDr 14 3 TDr 14 0 TDr 14	eccakusa 100158 101220 eccakusa	585.3602 7 324.3807 8 311.9655 7 273.3946 7	78.21251 30.70425 76.80316 78.21251	381.174 78 113.690 53 111.459 51 69.208 47	5.0720 0.00 2.4723 0.00 7.5808 0.00							





Stickiness

y Variet	У						By co	oking	j replic	ate			
Analysis of	Variance						Analy	/sis of Va	ariance				
Source	Sum DF Squa	nof ires Mea	in Square	F Ratio	Prob > F		Source		DF	Sum of Squares	Mean Squar	e F Ratio	Prob > F
variety Error C. Total	3 4348 105 5942 108 10290	0.14 1.44 1.58	14493.4 565.9	25.6104	<.0001*		cookin Error C. Tota	g replicate I	1 107 108	119.05 102782.53 102901.58	119.05 960.58	1 0.1239 4	0.7255
Means and S	Std Deviatio	ons					Mean	is and St	d Deviati	ons			
Level TDr 1400158 TDr 1401220 TDr 1401593 TDr meccakusa	Number 24 -1 29 -1 29 -1 27 -1	Mean 32.8333 1 27.5862 1 69.3448 3 17.5926 2	Std Dev 5.686235 9.629637 3.944572 20.296379	Std Err Mean 3.2019393 3.6451321 6.3033488 3.9060401	Lower 95% -139.457 -135.0529 -182.2567 -125.6216	Upper 95% -126.2096 -120.1195 -156.433 -109.5636	Level 1 2	Number 56 53	Mean -138.3929 -136.3019	Std Dev 31.717319 30.208624	Std Err Mean 4.238405 4.1494736	Lower 95% -146.8868 -144.6284	Upper 95 -129.89 -127.97
Connecting	g Letters R	eport Mean					Con	nectin	g Letter	s Repor	t		
TDr meccakus TDr 1401220 TDr 1400158 TDr 1401593	a A -11 A -12 A -13 B -16	7.5926 7.5862 2.8333 9.3448					2 1 Levels	A - ⁻ A - ⁻ s not con	Mean 136.3019 138.3929 nected by	same lette	er are signif	icantly diff	erent.
Ordered Diff	ferences Rep	ne letter a	re significa	antiy differe	ent.		0.1	10:0		D t			
Level	- Level	Difference	Std Err D	if Lower (L Upper C	p-Value	Orde	red Diff	rerences	Report			
TDr meccakusa TDr 1401220 TDr 1400158 TDr meccakusa	TDr 1401593 TDr 1401593 TDr 1401593 TDr 1400158	51.75223 41.75862 36.51149 15.24074	6.36194 6.24730 6.56463 6.67382	17 35.143 08 25.449 00 19.373 20 -2.182	68.3611 58.0682 53.6495 32.6638	 <.0001* <.0001* <.0001* <.0001* 0.1084 	Level 2	- Level 1	Differenc 2.09097	e Std Err 0 5.9394	Dif Lower 489 -9.683	CL Upper 337 13.86	CL p-Va 532 0.72

Stiffness/Hardness

y Variet	у							By co	okin	g replic	ate			
Analysis o	of Varia	nce						Analy	sis of \	/ariance				
Source	DF	Sum of Squares	Mean Sq	juare F	Ratio	Prob >	F	Source	•	DF	Sum of Squares	Mean Sq	uare FRat	io Prob>
variety Error C. Total	3 105 108	4034033.7 2333366.5 6367400.2	134 2	4678 60 2223	0.5096	<.0001	*	cookin Error C. Tota	g replicat I	te 1 107 108	134830.1 6232570.1 6367400.2	134 58	1830 2.31 3248	47 0.1311
Means and S	Std Devi	ations						Mean	s and S	td Deviati	ons			
Level	Number	Mean	Std Dev	Std Err Mean	Lower	95% Upp	er 95%	Level	Numbe	r Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
TDr 1400158 TDr 1401220 TDr 1401593 TDr mercakusa	24 29 29 27	846.125 738.37931 1120.4138 607 33333	203.11109 120.34932 135.47971 133.73884	41.459877 22.348307 25.15795 25.738051	760.3 692.6 1068. 554.4	5871 93 0088 78 8801 11	1.89129 4.15774 71.9475 0.23866	1 2	56 53	5 865.5 3 795.13208	248.86543 233.13087	33.256041 32.022987	798.8534 730.87325	932.146 859.390
Connectin	ng Lett	ers Rep	ort					Con	nectin	g Letters	Report			
Level TDr 1401593 TDr 1400158 TDr 1401220 TDr meccaku Levels not co	3 A 3 B) Jsa onnected	11 8 C 7 D 6 by same le	Mean 20.4138 46.1250 38.3793 607.3333 etter are sig	qnificantly	/ differe	ent.		Level 1 2 Levels	A 8 A 7 not cor	Mean 65.5000 95.13208 inected by s	same letter	are signifi	cantly diffe	rent.





By Varie	ety						By co	oking	g replica	ite				
Ordered D	ifferences Re	eport				Ordered Differences Report								
Level	- Level	Difference	Std Err Dif	Lower CL	Upper CL	p-Value	Level	- Level	Difference	Std Frr Dif	Lower CL	Upper Cl	p-Value	
TDr 1401593	TDr meccakusa	513.0805	39.86667	409.0022	617.1587	<.0001*	1	2	70 26702	46 25120	21 2107	162.0555	0 1211	
TDr 1401593	TDr 1401220	382.0345	39.14829	279.8317	484.2373	<.0001*	1	2	70.50792	40.20120	-21.5197	102.0555	0.1511	
TDr 1401593	TDr 1400158	274.2888	41.13677	166.8948	381.6828	<.0001*								
TDr 1400158	TDr meccakusa	238.7917	41.82100	129.6113	347.9720	<.0001*								
TDr 1401220	TDr meccakusa	131.0460	39.86667	26.9677	235.1242	0.0074*								
TDr 1400158	TDr 1401220	107.7457	41.13677	0.3517	215.1397	0.0489*								

Chewiness

By Varie	ty						By co	oking	replica	ate			
Analysis	of Varia	nce					Analy	sis of V	ariance				
Source	DE	Sum of	Maar	quara	E Ratio	Prob > F	Source		DF	Sum of Squares	Mean Sou	are FRati	o Prob > F
Jource	DF	Squares	iviean 5	quare	1 1 400		cookin	a replicate	1	8376.9	83	76.9 0.751	5 0.3880
variety	3	524002.2	1	/400/	27.0834	<.0001*	Error	5	107	1192794.9	111-	47.6	
Error	105	677169.6		6449			C. Tota	1	108	1201171.8			
C. Total	108	1201171.8											
Means and	Std Devia	tions					Mean	s and St	d Deviatio	ons			
				Std Err							Std Err		
Level	Number	Mean	Std Dev	Mean	Lower 95	% Upper 95%	Level	Number	Mean	Std Dev	Mean	Lower 95%	Upper 95%
TDr 1400158	24	237.82216	133.2795	27.205564	181.5431	7 294.10116	1	56	131.7501	69.96214	9.3490842	113.01412	150.48609
TDr 1401220	29	114.5476	67.751254	12.581092	88.77639	9 140.3188	2	53	149.28983	133.27143	18.306239	112.55567	186.02399
TDr 1401593	29	49.823595	12.09248	2.2455172	45.22386	1 54.423328							
		-	12102100	151510250		0 200137133							
Connectin	ng Letters	Report					Coni	necting	Letters	Report			
Level		Me	ean				Level		Mean				
TDr 1400158	S A	237.82	216				2	A 149	9.28983				
IDr meccaku	isa B	178.36	556				1	A 13	1.75010				
TDr 1401220) C	114.54	760				, Lovels	notconn	acted by cr	me letter a	re cionifica	nthy differen	+
IDr 1401593		D 49.82	359				Levels	not conn	ected by sa	ine letter a	re significa	inuy unterer	16
Levels not co	nnected by	same letter a	are significa	antly diffei	rent.								
Ordered Di	fferences	Report					Orde	red Diff	erences	Report			
Level	- Level	Differ	ence Std E	rr Dif Lo	wer CL Up	per CL p-Value	Laure 1	Laurel	D:#	CALL-1	1 Lawrence	CL Harris	
TDr 1400158	TDr 14015	93 187.	9986 22.	16090 13	0.1440 24	5.8531 <.0001*	Level	- Level	Difference		IT Lower	CL Upper	CL p-value
TDr meccakus	a TDr14015	93 128.	5420 21.	47668 7	2.4737 18	4.6103 <.0001*	2	1	17.5397	2 20.233	56 -22.5	710 57.65	040 0.3880
TDr 1400158	TDr 14012	20 123.	2746 22.	16090 6	55.4200 18	1.1291 <.0001*							
TDr 1401220	TDr 14015	93 64.	7240 21.	08968	9.6660 11	9.7820 0.0143*							
TDr meccakus	a TDr14012	20 63.	8180 21.	47668	7.7497 11	9.8862 0.0190*							
1Dr 1400158	1Dr mecca	kusa 59.	4566 22.	52951	0.6398 11	8.2734 0.0465*							

Gumminess

By Variet	y						By co	ooking	replic	ate			
Analysis o	of Varia	ance					Anal	ysis of V	ariance				
Source	DF	Sum of Squares	Mean Sq	uare Fl	Ratio Pro	b > F	Source	e	DF	Sum of Squares	Mean Squ	iare F Rati	o Prob > F
variety Error	3 105	420408.51 350735.75	140	0136 41 3340	.9527 <.0	001*	cookin Error	ig replicate	e 1 107	1445.25 769699.01	144 719	5.25 0.200 3.45	9 0.6549
C. Total	108	771144.26					C. Tota	al	108	771144.26			
Means and	Std Dev	iations					Mear	ns and St	d Deviatio	ons			
Level	Numbe	r Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%	Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
TDr 1400158 TDr 1401220	24	4 391.58333 9 260.75862	78.997477	16.125293 10.517714	358.22562 239.21406	424.94104 282.30318	1 2	56 53	294.625 287.33962	57.815557 106.1434	7.7259288 14.579917	279.14189 258.08288	310.10811 316.59637
TDr 1401593 TDr meccakusa	21	7 309.51852	59.320103	11.416159	286.05227	332.98477							





By Variet	у						By cooking replicate						
Connecting Letters Report							Conr	necti	ng Letters Re	eport			
Level TDr 1400158 TDr meccaku TDr 1401220 TDr 1401593	A sa B C D	Mean 391.58333 309.51852 260.75862 221.06897				LevelMean1A294.625002A287.33962Levels not connected by same letter are significantly different.							
Levels not co	nnected by san	ne letter are	significantly	y different.			Orde	red E	Differences R	eport			
Level	- Level	Difference	Std Err Dif	Lower CL	Upper CL	p-Value			1 0.00				
TDr 1400158 TDr 1400158 TDr meccakusa TDr 1400158 TDr meccakusa TDr 1401220	TDr 1401593 TDr 1401220 TDr 1401593 TDr meccakusa TDr 1401220 TDr 1401593	170.5144 130.8247 88.4496 82.0648 48.7599 39.6897	15.94882 15.94882 15.45641 16.21410 15.45641 15.17789	128.8774 89.1878 48.0982 39.7353 8.4085 0.0654	212.1513 172.4616 128.8009 124.3943 89.1113 79.3139	<.0001* <.0001* <.0001* <.0001* 0.0111* 0.0495*	1	2 2	7.285377	16.25361	-24.9355	39.50627	0.6549

Cohesiveness

By Varie	ty						By cooking replicate										
Analysis o	of Varia	nce				1	Anal	ysis of V	ariance								
Source	DF	Sum of Squares	Mean Squar	e F Ratio	Prob > F		Source	e	DF	Sum of Squares	Mean Sq	uare FRa	ntio Prob>F				
variety Error C. Total	3 1 105 2 108 4	.9636944 2.1944115 .1581060	0.65456 0.02089	5 31.3202 9	2 <.0001*		cooking replicate Error C. Total		cooking replicate 1 Error 107 C. Total 108		cooking replicate 1 0.03 Error 107 4.12 C. Total 108 4.15		e 1 0.0333314 0. 107 4.1247746 0. 108 4.1581060		0.03 0.03	3331 0.8 8549	646 0.3545
Means and	Std Dev	/iations					Mear	is and St	d Deviati	ons							
Level TDr 1400158 TDr 1401220 TDr 1401593 TDr meccakus	Numbe 2 2 2 3 2	er Mea 4 0.507834 9 0.369174 9 0.198380 7 0.53347	n Std Dev 7 0.219695 1 0.1313578 6 0.0257041 5 0.1496997	Std Err Mean 0.0448451 0.0243925 0.0047731 0.0288097	Lower 95% 0.4150696 0.3192083 0.1886093 0.4742542	Upper 95% 0.6006077 0.41914 0.2081639 0.5926927	Level 1 2	Number 56 53	Mean 0.3779528 0.4129399	Std Dev 0.1577784 0.2302007	Std Err Mean 0.021084 0.0316205	Lower 95% 0.3356995 0.3494887	Upper 95% 0.4202061 0.4763911				
Connecti	ng Lette	ers Repo	ort				Con	nectin	g Letter	s Repor	t						
TDr meccaki TDr 140015 TDr 140122 TDr 140159 Levels not co	usa A B A D B 3 onnected	0.5334 0.5078 0.3691 C 0.1983 by same le	lean 7347 3868 7414 8658 tter are signit	ficantly diff	erent.		Leve 2 1 Levels	A 0.4 A 0.3 s not con	Mean 41293992 37795281 mected by	same lette	er are sigr	iificantly d	ifferent.				
Ordered Di	fference	es Report					Orde	red Diff	ferences	Report							
Level TDr meccakus TDr 1400158 TDr 1401220 TDr meccakus TDr 1400158 TDr meccakus	- Level a TDr 140 TDr 140 TDr 140 a TDr 140 TDr 140 TDr 140 a TDr 140	Diffe 1593 0.33 1593 0.30 1593 0.17 1220 0.16 1220 0.13 0158 0.02	rence Std Err 50869 0.038 94521 0.039 07876 0.037 42993 0.038 86645 0.039 56348 0.040	Dif Lowe 6614 0.234 8931 0.209 9647 0.077 6614 0.063 8931 0.034 5566 -0.086	r CL Upper \$1155 0.43601 \$305 0.41359 \$1675 0.26990 \$368 0.26523 \$517 0.24283 \$245 0.13151	CL p-Value 186 <.0001*	Level 2	- Level 1	Difference 0.034987	e Std Err D 1 0.037626	if Lower 51 -0.039	CL Upper 602 0.1095	r CL p-Value 3765 0.3545				

Springiness

rie	ty				
Analysis	of Var	iance			
Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
variety Error C. Total	3 105 108	2.1886987 2.0561207 4.2448194	0.729566 0.019582	37.2568	<.0001*





В	By Variety								By cooking replicate							
	Means and	Std Devia	tions					Means and Std Deviations								
	Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%		Loval	Number	Moon	Std Dov	Std Err	Lower 05%	llanar 05%	
	TDr 1400158	24	0.5725394	0.2071419	0.0422827	0.485071	0.6600078		1	Number	0.4220257	0 1505102	0.0211020	0.2012042	0.4662972	
	TDr 1401220	29	0.4141124	0.1346537	0.0250046	0.3628929	0.4653319		2	50	0.4236537	0.1363165	0.0211029	0.3013042	0.4002672	
	TDr 1401593	29	0.2228203	0.0297648	0.0055272	0.2114984	0.2341423		2	23	0.4448209	0.2341424	0.0321019	0.3802893	0.5093045	
	TDr meccakusa	27	0.5592086	0.143681	0.0276514	0.5023703	0.6160469									
	Connectin	g Letters	s Report						Con	necting	g Letters	Report				
	Level		Mea	in					Leve		Mean					
	TDr 1400158	Α	0.5725394	10					2		4402601					
	TDr meccakus	a A	0.5592086	51					2	A 0.4	4482091					
	TDr 1401220	В	0.4141123	37					1	A 0.4	2383572					
	TDr 1401593	Č	0.2228203	34					Levels	not con	nected by	same letter	are signifi	cantly diffe	rent.	
	levels not cor	nected by	came latter	r ara cignifi	cantly diffe	ent										
	Levels not cor	inected by	same letter	are signin	cantiy unre	enu										
	Ordered Dif	ferences F	Report						Orde	red Diff	ferences F	leport				
	Level	- Level	Differe	nce Std Er	Dif Lowe	r CL Upper C	L p-Value		level	- Level	Difference	Std Frr D	if Lower	L Unner (I n-Value	
	TDr 1400158	TDr 140159	3 0.3497	7191 0.038	6156 0.248	907 0.450531	2 <.0001*		Lever	- Level	Difference	Stutino	a cost			
	TDr meccakusa	TDr 140159	3 0.3363	3883 0.037	4234 0.238	689 0.434087	79 <.0001*		2	1	0.0209912	0.038115	-0.0545	0.09055	2 0.5830	
	TDr 1401220	TDr 140159	3 0.1912	2920 0.036	7490 0.095	353 0.287231	1 <.0001*									
	TDr 1400158	TDr 140122	0 0.1584	1270 0.038	6156 0.057	615 0.259239	0.0005*									
	TDr meccakusa	TDr 140122	0 0.1450	0962 0.037	4234 0.047	397 0.242795	8 0.0010*									
	TDr 1400158	TDr meccak	usa 0.0133	3308 0.039	2579 -0.089	158 0.115819	0.9864									

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 & Springines (r = 0.95)
- Gumminess & Sppringiness (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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