Laboratory Standard Operating Procedure

SOP for the Instrumental Determination of Extensibility of Pounded yam

Biophysical Characterization of Quality Traits, WP2

Montpellier, France, 2022

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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 previously 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 panellists and from consumers participating in activities.

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RTBfoods

WP2: Biophysical Characterization of Quality Traits

SOP: Instrumental Determination of Extensibility[1] of Pounded yam

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[1] For the stretching character of pounded yam, the term "elastic" has often been misused

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ABSTRACT

Pounded yam is a glutinous dough product made from yam tubers often consumed in bolus form along with stews or soups. It is considered a common cuisine in West Africa in countries like Nigeria, Benin, Ghana, Cameroon and Ivory Coast. Often mislabelled as 'fufu' in some cultures, pounded yam is prepared by peeling mature yams, washing, dicing, cooking, and pounding into a uniform consistency. Pounded yam is often preferably made from *Dioscorea rotundata* varieties of yam, and less often prepared from the *Dioscorea alata* varieties. This may be associated with the traditional consumer preference for a sufficiently doughy, stretchable, mouldable, and acceptably firm pounded yam. These quality attributes may be measured instrumentally by the use of texture analysers and can be possibly correlated with human sensory perception scores.

The standard operating protocol (SOP) for determination of extensibility of pounded yam is based on its viscoelastic property. It measures how extensible the dough is when made into a sheet of about 1.5 mm thickness and a uniaxial force is exerted by a standard P/1SP probe under fixed test conditions. The conditions are: test mode: compression, load module: 5 kg, pre-test speed: 5 mm/s, test speed: 1 mm/s, post-test speed: 10 mm/s, trigger force: 5 g, target mode: distance, Distance: 40 mm.

The repeatability of cooking replicates and ANOVA to classify four contrasting yams of varying textural quality were conducted. Correlations between sensory, instrumental, and consumer overall likeability provided relationships between measurable and discernible extensibility of pounded yam.

Key Words: Extensibility, Stretchability, Pounded yam, Texture analyzer, Yam, Sensory analysis, Consumer likeability

1 SCOPE AND APPLICATION

This SOP describes the method for determining the extensibility of pounded yam prepared using the SOP (Otegbayo et al., 2022), and a texture analyser under fixed conditions.

The SOP may be used to determine the texture attribute extensibility of pounded yam by instrumental measurement of extensibility of the pounded yam dough sheet.

2 REFERENCE

Bolanle Otegbayo, Oluyinka Oroniran, Abiola Tanimola, Oluwatomilola Bolaji and Ayomide Alamu (2022). Standard Operating Protocol for Textural Characterization of Pounded Yam. Iwo, Osun State, Nigeria: RTBfoods Laboratory Standard Operating Procedure, 21 p.

3 DEFINITIONS

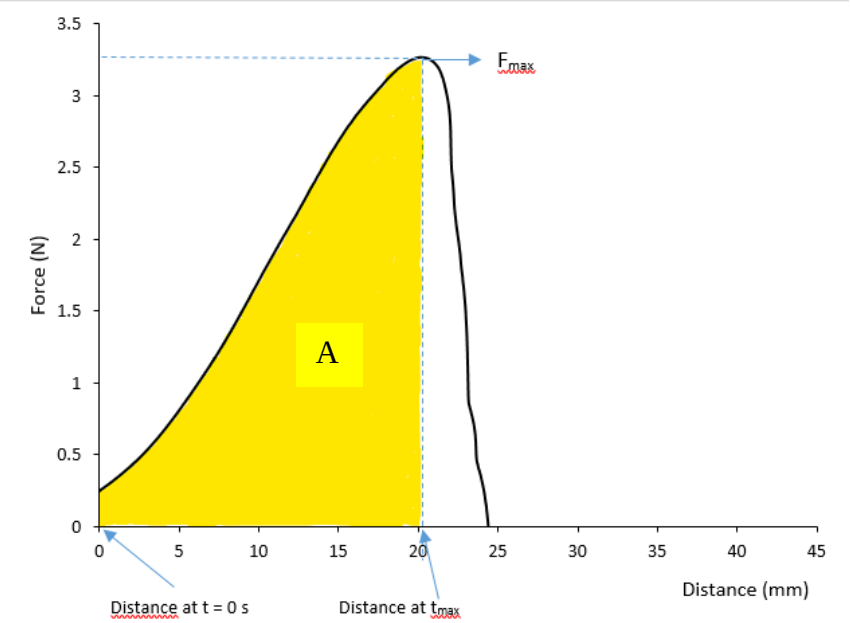

Fig 1 Exemplary instrument texture profile of extensibility of pounded yam dough sheet

Hardness (N): the maximum force (F_{max}) required for the standard probe to break through the pounded yam dough sheet as captured by the texture analyser (Fig 1). It is the force recorded at the point of structural failure (t_{max}).

Area between t_o and F_{max} (N.s): the area (A) under the curve from initiation of the test until the point of the structural failure of the pounded yam dough sheet at time t_{max} (Fig 1). It represents the amount of energy required to fully stretch the pounded yam dough sheet just until structural failure.

Extensibility (mm): the distance between the time at initiation of test (t_o) and time at point of structural failure (t_{max}) as shown in Fig 1. It represents how much displacement the pounded yam

dough sheet can sustain before structural failure, thus, representative of the stretchability of the pounded yam dough sheet.

Stretchability (-): the ability of the pounded yam dough to extend until breaking apart. It represents the extent of the stretching distance before the dough breaks when it is molded by the fingers. It is assessed by the mean sensory score of a quantitative descriptive analysis (QDA) on a scale of 0 to 10, 0 meaning 'not stretchable at all' and 10 meaning 'very stretchable'.

Mouldability (-): the ability of the pounded yam dough to be rolled and pressed between the palm of the hands while remaining compact. It is assessed by the mean sensory score of a quantitative descriptive analysis (QDA).

Consumer overall likeability (-): the mean sensory score of a consumer analysis of the overall likeability of the pounded yam dough on a scale of 1 to 9, 1 meaning 'extremely disliked', and 9 meaning 'extremely liked'.

4 PRINCIPLE

The standard operating protocol (SOP) for determination of extensibility of pounded yam is based on its viscoelastic property. It measures how extensible the dough is when made into a sheet of about 1.5 mm thickness and a uniaxial force is exerted by a standard P/1SP probe under fixed test conditions.

5 REAGENT

Paraffin oil (chemical grade)

6 APPARATUS

- Texture analyser (TA-XT Plus, Stable Micro Systems Ltd., Surrey, UK) with *Exponent* Software Interface
- P/1SP standard ball probe
- Test rig
- Yam Pounder (QZP/6000 model, Cheerfengly Ind. Co. Ltd, Taipei, Taiwan)
- Infra-red thermometer
- Chronometer
- Bowls
- Plastic cups with threaded covers
- Incubator (WTC binder, Tuttlingen, Germany)
- Sharp stainless steel knives
- Cutting boards
- Mass balance ±0.01 g (Precisa, Precisa Gravimetrics AG, Switzerland)
- Plastic spoon
- Pasta roller (model 150 mm Deluxe, Italy)
- Digital Vernier calliper

7 PROCEDURE

7.1 Calibration of texture analyser

The probe height and force are calibrated following the calibration instructions provided in the operation manual. The force calibration is done using a 2 kg standard weight. Calibration of probe distance (40 mm) is done afterwards. The test probe used is a P/1SP compression ball probe (Fig 2) with the tortilla/pastry burst rig (HDP/TPB).

Fig 2 The P/1SP probe with attachment

7.2 Test conditions for measurement of extensibility

The following textural parameter settings were considered for the measurements:

- Test mode: compression
- Test probe : P/1SP
- Load module: 5 kg
- Pre-test speed: 5 mm/s
- Test speed: 1 mm/s
- Post-test speed: 10 mm/s
- Trigger force: 5 g
- Target mode: distance
- Distance: 40 mm

7.3 Preparation of pounded yam dough sheet and measurement

The pounded yam dough is prepared following the RTBfoods SOP for pounded yam sample preparation recommended for texture analysis with some modifications as described below.

Step 1: Two yam tubers are cut longitudinally into two halves and the proximal and distal sections are cut off from both ends (Fig 3).

Step 2: From the two central sections, cubes of about 2 cm dimension are cut from both representative central sections (Fig 4).

Fig 3 Longitudinal halves of yam tubers

Fig 4 Yam cubes cut from representative central sections

Step 3: 450 g of the yam cubes is weighed and placed in the cooking chamber of the yam pounder (Fig 5) above its receptacle containing 250 mL of water. The yam cubes are cooked for about 21 - 24 minutes when the alarm sounds, and pounded for 1.5 minutes to produce the yam dough.

Fig 5 Yam pounder

Fig 6 Plastic cups/vials

Step 4: The yam dough is spooned out and rolled between the palms of the hands into balls of 43 - 50 g and placed in plastic cups (Fig 6) and covered.

Step 5: These are then placed in an incubator at 55 °C for 12 - 20 minutes to allow for stress relaxation and temperature equilibration. The time range is due to the sequence of placement and retrieval of sample in and from incubator, since it is not practical to measure all samples at once.

Step 6: Afterwards, the dough is rolled into a sheet of about 1.5 mm thickness using a pasta roller at knob setting 6 (Fig 7).

Fig 7 Pasta roller

Step 7: The dough sheet is placed on the test rig (Fig 8) and the surface temperature was monitored with an infra-red thermometer (Fig 9) until it reached 30 °C. The test is finally conducted in replicates under the selected test conditions using the P/1SP probe.

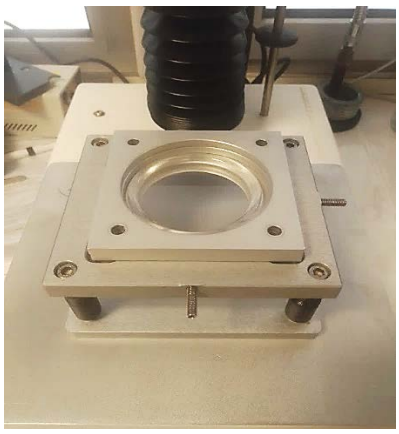

Fig 8 Test rig

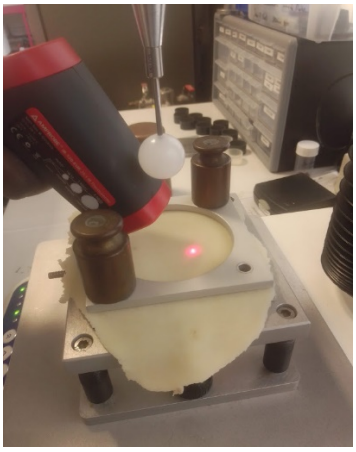

Fig 9 Measuring temperature of dough sheet using infra-red thermometer

8 EXPRESSION OF RESULTS

8.1 Statistics

8.1.1 Analysis of Variance (ANOVA)

The significant differences between mean instrument texture of the varieties are determined as shown in Annex 1.

8.1.2 Repeatability

The repeatability of an exemplary test (Annex 1) can be determined by conducting a t-test statistic on the replicate data. Each replicate may consist of from 3 measurements up to 8 measurements. The replicates may not be significantly different ($P > 0.05$) from one another to be considered as repeatable measurements. Accuracy of data are evaluated from standard error (std err) and coefficient of variation (CV).

9 CRITICAL POINTS OR NOTE ON THE PROCEDURE

- It must be ensured that the texture analyser is switched on at least 15 minutes prior to measurements and the texture analyser must be calibrated for force and distance on each experiment day prior to measurements.
- The temperature of the dough sheet must be monitored and measurement must be done at 30 °C. Large variations in temperature may result in inaccurate results as the dough sheets retrograde rapidly.
- It may be necessary to clean the pasta roller and test probe periodically with moist tissue to remove residues. Paraffin oil may be applied between rollers and wiped off before rolling dough into sheet.
- It must be ensured that the dough sheet is not sagging on the test rig before measurement.
- The dough must be relaxed for a period of 12-20 minutes prior to rolling into sheets. This may be due to the stress caused by deformation during preparation of the dough; otherwise, it may result in a rough surface that is difficult to roll into a smooth sheet.
- The extensibility of pounded yam dough sheet made from yams having very poor sheet-forming ability (especially *D alata* varieties) may be difficult to measure using this protocol. For instance, the variety *Aga* was not amenable to this protocol (Fig 10) while the variety *Irindou* was slightly difficult to roll into sheet except with careful effort as observed from the rough edge (Fig 11).

Fig 10 Yam variety (Aga) impossible to form dough sheet

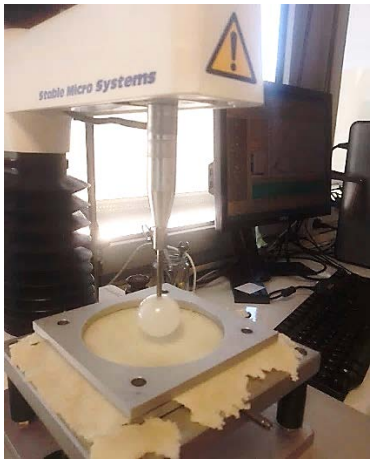

Fig 11 Variety (Irindou) with slight difficulty in dough sheet formation showing rough edge

10 TEST REPORT

Exemplary test results are discussed in the appendices.

11 APPENDICES

11.1 Annex 1:

Varieties : *Aga*, *Irindou*, *Laboko*, *Wete*

Table 1 Exemplary statistical accuracy of instrumental texture parameters

Texture parameter	variety	cooking replicate	N	Mean	Std Dev	Std Err of mean	CV of mean
Hardness (N)	Irindou	1	5	0.459	0.154	0.069	33.4
		2	3	0.385	0.062	0.036	16.2
	laboko	1	7	2.351	0.761	0.288	32.4
		2	5	1.134	0.326	0.146	28.8
	wete	1	8	0.988	0.190	0.067	19.2
		2	7	1.160	0.230	0.087	19.8
Stretchability (N.mm)	Irindou	1	5	2.761	1.502	0.672	54.4
		2	3	1.931	0.794	0.458	41.1
	laboko	1	7	19.076	2.288	0.865	12.0
		2	5	16.573	3.008	1.345	18.2
	wete	1	8	10.949	2.018	0.714	18.4
		2	7	11.282	1.098	0.415	9.7
Area between t_o and F_{max}	Irindou	1	5	1.083	0.706	0.316	65.2
		2	3	0.645	0.310	0.179	48.0
	laboko	1	7	25.577	9.058	3.423	35.4
		2	5	12.612	4.926	2.203	39.1
	wete	1	8	5.205	1.831	0.647	35.2
		2	7	6.064	1.430	0.540	23.6

NB: data outliers were not removed. Outliers can be removed by statistical analysis

ANOVA and repeatability of instrumental texture attributes

Table 2 Exemplary ANOVA and repeatability for Area between t_o and F_{max} (N.s)

By Variety

One way Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
variety	2	2183.9927	1092.00	31.1810	3.059e-8
Error	32	1120.6780	35.02		
C. Total	34	3304.6708			

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
Irindou	8	0.919	0.602921	0.2131648	0.4149454	1.4230546
laboko	12	20.175	9.9070146	2.8599088	13.880383	26.469617
wete	15	5.6056667	1.6582068	0.4281471	4.6873824	6.523951

Connecting Letters Report

Level		Mean
laboko	A	20.175000
wete	B	5.605667
Irindou	B	0.919000

Levels not connected by same letter are significantly different.

Ordered Differences Report

Level	- Level	Difference	Std Err Dif	Lower CL	Upper CL	p-Value
laboko	Irindou	19.25600	2.701126	12.6183	25.89367	<.0001*
laboko	wete	14.56933	2.291981	8.9371	20.20158	<.0001*
wete	Irindou	4.68667	2.590829	-1.6800	11.05330	0.1828

By cooking replicate

One way Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
cooking replicate	1	147.0493	147.049	1.5368	2.238e-1
Error	33	3157.6215	95.685		
C. Total	34	3304.6708			

Effect Tests - 2 way ANOVA

Source	Nparm	DF	Sum of Squares	Mean Square	F Ratio	Prob > F
variety	2	2	1853.1776	926.5888	42.8407	2.198e-9
cooking replicate	1	1	137.5467	137.5467	6.3594	1.742e-2
variety*cooking replicate	2	2	346.2007	173.1003	8.0033	1.707e-3

Means and Std Deviations

Level	Number	Mean	Std Dev	Std Err Mean	Lower 95%	Upper 95%
1	20	11.30475	12.060725	2.6968601	5.660157	16.949343
2	15	7.1628	5.3040475	1.3694992	4.2255164	10.100084

Connecting Letters Report

Level		Mean
1	A	11.304750
2	A	7.162800

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	4.141950	3.341154	-2.65572	10.93962	0.2238

A one-way ANOVA shows that significant effects in textural attributes (for example area between t_o and F_{max}, shown in Table 2) were found between the varieties alone, suggesting that they are different in textural quality from one another. The cooking replicates were reproducible considering that they had no significant effect on textural attributes alone. Variety played a more significant effect than cooking replicate.

A two-way ANOVA, however, shows that the textural attribute also significantly depends on the interplay between variety*cooking replicate.

Pearson correlations between instrument and sensory texture and consumer overall likeability

For only 3 cultivars, the correlations between instrument, sensory and consumer overall likeability attributes were high, but only stretchability and area between t_o and F_{max} had significant correlation (Table 3). This means that the sensory stretchability of pounded yam was significantly associated with the amount of work required for the pounded yam sheet to stretch until structural failure.

Table 3 Pearson correlation of instrument, sensory and consumer overall likeability attributes

	hardness (N)	extensibility (mm)	area between t_o and F_{max} (N.s)	stretchability	mouldability	consumer overall likeability
extensibility (mm)	0.993	1.000				
area between t_o and F_{max} (N.s)	0.973	0.939	1.000			
stretchability	0.988	0.962	0.997	1.000		
mouldability	0.870	0.923	0.734	0.783	1.000	
consumer overall likeability	0.879	0.815	0.965	0.942	0.529	1.000
	Probability					
extensibility (mm)	0.077	<.0001				
area between t_o and F_{max} (N.s)	0.147	0.224	<.0001			
stretchability	0.099	0.176	**0.0485**	<.0001		
mouldability	0.328	0.251	0.476	0.427	<.0001	
consumer overall likeability	0.316	0.393	0.169	0.217	0.645	<.0001

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