Laboratory Standard Operating Procedure

Standard Operating Protocol for Textural Characterization of Pounded Yam

Biophysical Characterisation of Quality Traits, WP2

Iwo, Nigeria, 25/02/2022

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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 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 panellists and from consumers participating in activities.

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RTBfoods

WP2: Biophysical Characterization of Quality Traits

SOP: Standard Operating Protocol for Textural Characterization of Pounded Yam

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ABSTRACT

This document presents the Standard Operating Procedure (SOP) for instrumental texture evaluation of pounded yam developed by Bowen University team in Periods 3 and 4. The objective of this SOP was to develop and establish procedure for instrumental textural quality measurement for pounded yam prepared from varieties of yam tubers using a texture analyser. The results of the test showed that this method of texture evaluation is repeatable and discriminant. This was achieved and validated by CIRAD texture experts.

Key Words: Texture profile analysis (TPA), Textural attributes, pounded yam, *Dioscorea species*

1 SCOPE AND APPLICATION

The objective of this SOP is to develop and establish procedure for instrumental textural quality measurement for pounded yam samples prepared from varieties of yam tubers using a texture analyser.

2 PREREQUISITE

The setting up and managing of a sensory tasting panel was explained in the deliverable: RTBfoods_F.2.2_2018.pdf

3 REFERENCES

1. Otegbayo, B.O., Aina, J.O., Lawrence, A., Sakyi-Dawson, E.O., Bokanga, M. and Asiedu, R. (2007). Texture profile analysis applied to pounded yam. Journal of Texture Studies**.** Vol. 38 No 3: 355-372.
2. Mohsenin, N.N. (1986). Rheological properties. In: Physical properties of plant and animal materials.2nd ed. Gordon and Breach, Science publishers Inc. New York. pp 225-227
3. Bourne, M.C. (2002). Food Texture and Viscosity; Concept and Measurement, 2nd Ed., pp. 257–290, Academic Press, London, U.K.

4 DEFINITIONS OF TERMS

Vocabularies used in the instrumental Texture Profile Analysis (ITPA) of pounded yam samples are presented in Table 1

Table1 Vocabulary used in instrumental Texture Profile analysis of pounded yam samples

Attributes	Sensorial description (as applied to pounded yam)	Instrumental description	Modified definition as applied to Pounded yam
Adhesiveness/ Stickiness	This is when the pounded yam sticks or adhere to the fingers when touched or during moulding into bolus for swallowing.	This is the ability of the sample to stick to probe after deformation. This is the negative force area of the first bite. It is the force necessary to pull the plunger away from the sample.	This is when the pounded yam samples stick to the probe after deformation.

Attributes	Sensorial description (as applied to pounded yam)	Instrumental description	Modified definition as applied to Pounded yam
Cohesiveness	Ability of the pounded yam to stick together easily without disintegrating, or being cohesive and being easy to mould.	This is the ratio of the positive force areas during the second compression to that during the first compression (Area2/Area1) or how a product withstands a second deformation relative to how it behaved under the first deformation.	The ability of the pounded yam to adhere or stick together under a compressive force (probe) after deformation.
Hardness	Hardness is when force is used to compress the sample or takes effort to compress the sample	Ability of sample to resist deformation. A soft product is one that displays a slight resistance to deformation, a firm product is moderately resistant to deformation, while hardness describes a product which shows substantial resistance to deformation	Hardness is the peak force used to compress the pounded yam sample.
Springiness:		The distance that the food recovered in its height during the time that elapsed between the end of the first bite and the start of the second bite is defined as springiness (Bourne 1978).	This may be a component of the stretchability of the pounded yam.
Stringiness/resilience		This is the distance a product stretches as the compressing plunger is pulled away at the end of the first bite or the distance the product was extended during decompression before breaking off (Bourne 1978). Stringiness is also defined as how well a product fight to regain its original position.	Resilience or stringiness is the distance that the pounded yam stretches as the compressing plunger is pulled away from the product at the end of the first bite.

5 PRINCIPLE

The ITPA method involves the use of a texturometer (model TVT 6700, Perten instruments, USA) which imitates or simulates the mastication of the human jaw. It involves compressing a bite-size piece of food two or more times in a reciprocating motion that simulates the action of the jaw. The resulting force–time or force-distance curve follows a sine-wave pattern generated (Fig 1). This is then used to quantify textural parameters that correlate well with results from sensory evaluation (Bourne, 2002). The instrumental texture profile analysis is a two-bite test cycle.

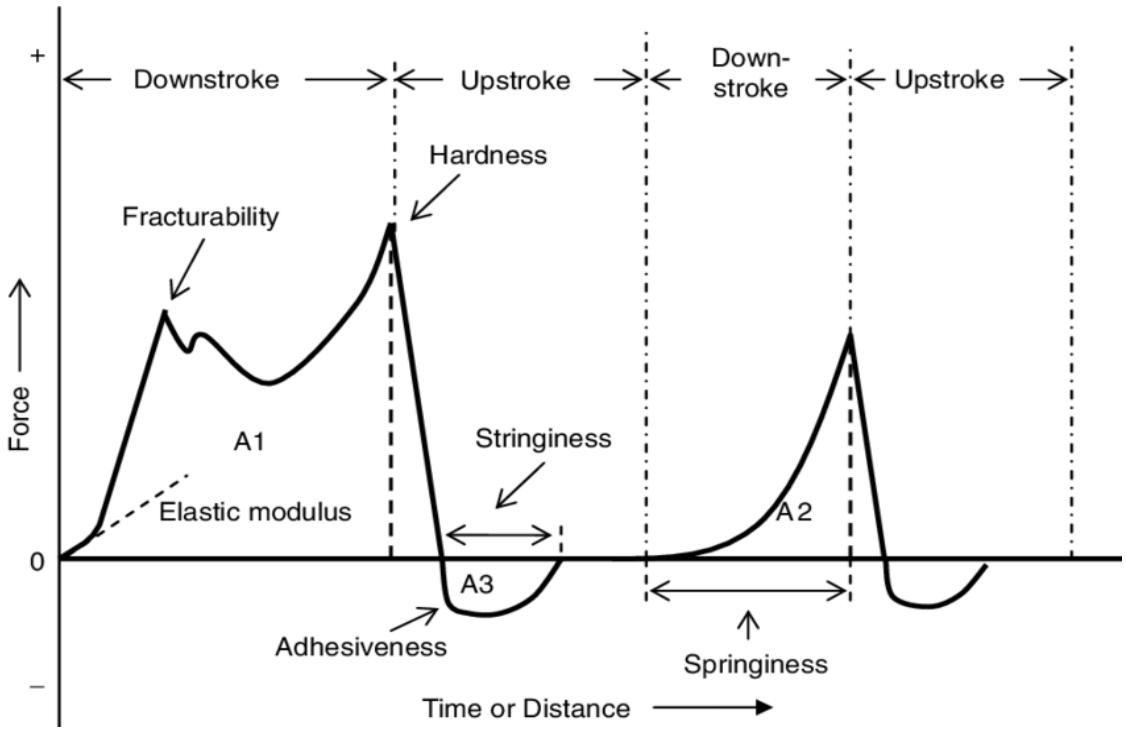


Fig 1 **Generalized Texture Profile Analysis curve**

Source: Bourne (2002)

6 EQUIPMENT

Texturometer (model TVT 6700, Perten instruments, USA) equiped with a 10 kg load cell.

7 PROCEDURE

7.1 Product Preparation under laboratory conditions

The pounded yam preparation follows the procedure described in the SOP for preparation and sensory profiling of pounded yam (RTBfoods_F.2.2_2018.pdf).

7.1.1 Packing

- For Instrumental texture profile analysis (ITPA) the pounded yam is packed in small cylindrical plastic moulds of dimension 3 cm diameter x 3.6 cm height (Fig. 2a & b). The mould is to ensure a uniform dimension (size and shape to reduce variation because the test is dimension sensitive) for the samples. The mean sample weight is 25 g.
- The packing may take 5 minutes when handled by two people, and the temperature of the pounded yam which was initially at 68°C after cooking and pounding may drop to between 45 – 55 °C before measurement.
- A means of maintaining the temperature should be devised such as packing it in a styrofoam box or putting it in an electrically heated lunch box briefly. (Fig. 2c & d). This is to maintain the temperature all through the instrumental evaluation.

a. Moulds

b. samples in mould

c. Heating bowl

d. heating bowl

Fig. 2 Packaging of Pounded yam samples before analysis to have uniform dimension

7.1.2 Sample storage

Keep the samples in a medium that can keep the temperature between 45 – 50 ^{o}C untill instrumental texture analysis. This may be done using a heating lunch bowl (Fig. 2c & d).

At the point of texture measurement, an hand held infra-red thermometer was used to monitor temperature.

7.2 Instrumental Texture analysis

7.2.1 Steps/Procedure in running a test

The steps for running instrumental texture profile analysis on a sample involves:

- Calibration:

Calibrate the height of probe and the force applicable on the instrument with a 2 kg standard weight before the beginning of texture analysis.

- Probe selection:
  For pounded yam, use flat-ended cylinder compression probe of 75 mm diameter and 45 mm height

- Texture Analyser parameters selection
  - Load cell of texture analyser 10kg
  - Pre-test speed of 5.0 mm/s
  - Test speed of 2 mm/s
  - Post-test speed of 2 mm/s
  - Trigger force of 5g
  - Data capture rate of 200 points per second (pps)
  - Distance above trigger of 20 mm
  - Time between compression cycles of 5 sec
  - Strain of 50 %
  - Temperature of sample at measurement is 45°C

Instrumental Textural quality attributes of significance to pounded yam are adhesiveness, cohesiveness and hardness

The steps for running instrumental texture profile analysis on a sample involves:

- Attach the flat-ended cylinder probe (45mm high and 75mm diameter) (Fig 3)
- Calibrate the height and weight of the instrument
- Carefully remove the sample from the plastic mould, check that the temperature is stable at 45°C, and place gently on the stationary horizontal platform of the instrument (Fig. 3).
- Initiate the test through the software menus.
- The flat ended cylinder probe (45mm high and 75mm diameter) contacts the food sample, in a two-bite cycle.
- During the analysis two compressions will be made on the pounded yam samples, each at 50 % strain of the samples using a time interval of 5s between strokes.
- The stress that developed in the food sample is measured as the sample is compressed.
- Quantity of sample: Each sample in the plastic mould for instrumental texture evaluation is between 24 - 27 g sample weight and 29 - 34 mm sample height.
- Each sample should be replicated at least ten times

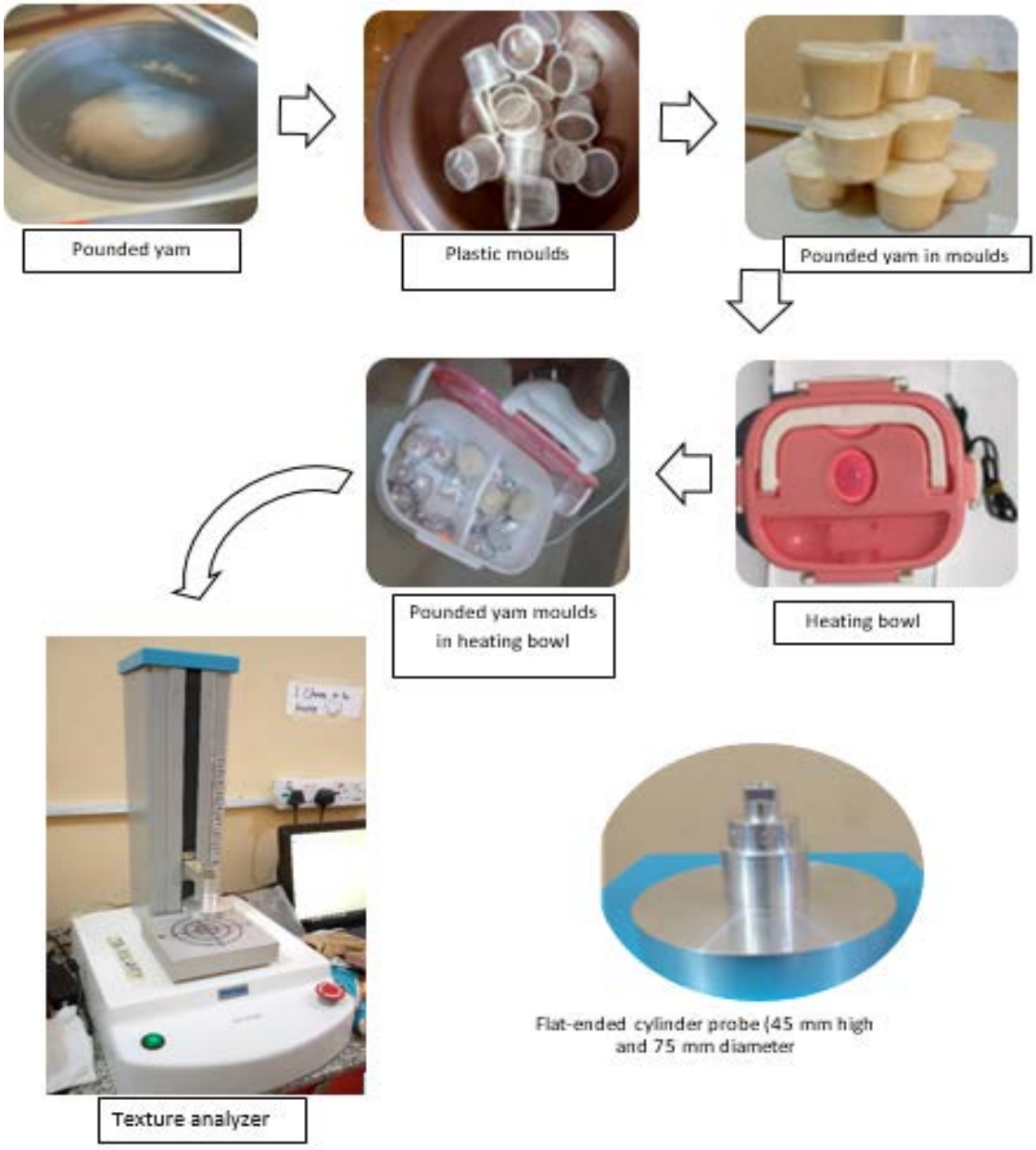


Fig 3 Steps in running instrumental texture profile analysis on pounded yam

8 EXPRESSION OF RESULTS

8.1 Interpretation of Texture profile Analysis (TPA) graph of pounded yam

Fig. 4 a shows an example of a TPA profile (from Texture Technologies) and Figs 4 b-h shows the TPA profile of pounded yam. The steepness of the slope denotes its degree of firmness. The steeper the slope, the firmer the pounded yam. The softness of the pounded yam is denoted by the concave

shape of the initial part of the curve towards the force axis. This is similar to what was reported by Mohsenin (1986) that initial part of soft biological tissues is usually concave towards the force axis.

Figure 4c shows the TPA profile of pounded that is moderately firm, less sticky, cohesive (but less cohesive because Area 2 is less than Area 1.) Fig 4d shows the profile of pounded yam that is soft, not steep (with a shoulder compared with Fig 4c) sticky and incohesive but less cohesive because Area 2 is less than Area 1.). In both Figs 4c & d, the cohesiveness is small (Area 2 is smaller in size than Area 1; this does not indicate a good degree of cohesiveness). Based on description of typical force-deformation curve of biological materials by Mohsenin (1986), the TPA curve of a hard/firm pounded yam from this study was similar to that of dry polymeric materials which is usually convex towards the force axis while that of soft pounded yam is similar to that of soft biological materials with the force deformation curve concave towards the force axis. (Appendix 1). Fig 4f shows a pounded yam sample that is less hard than that of Fig 4g, less adhesive/sticky (the adhesiveness area is smaller compared to fig 4g).

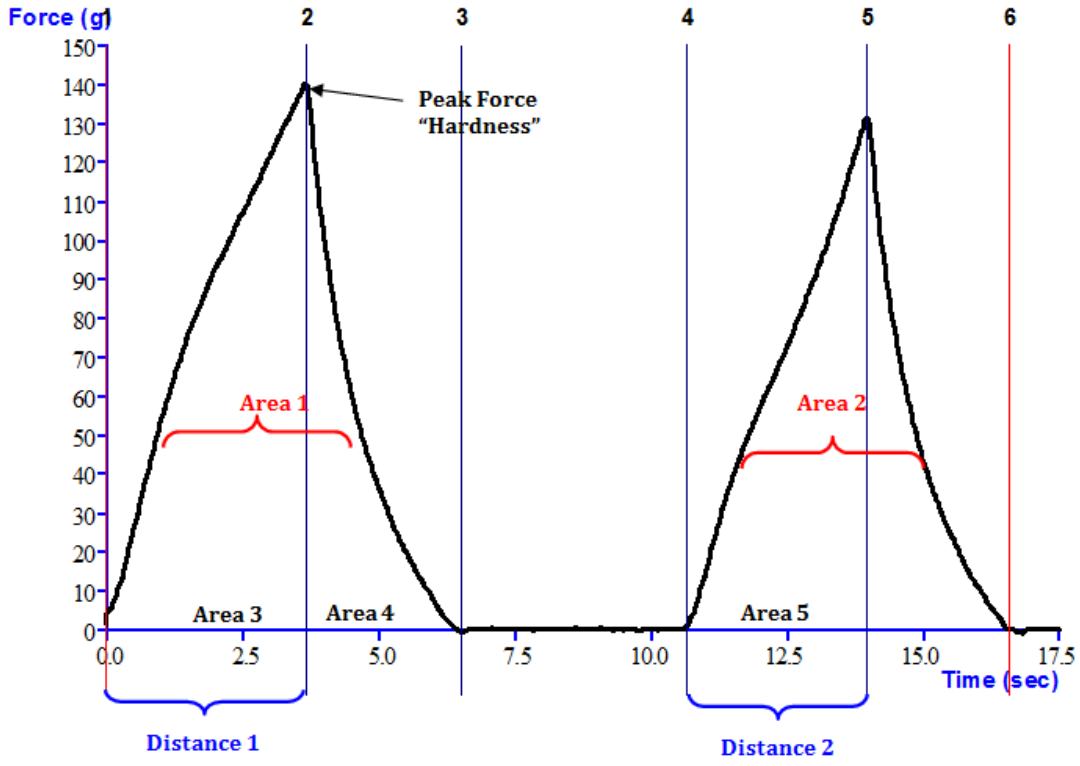
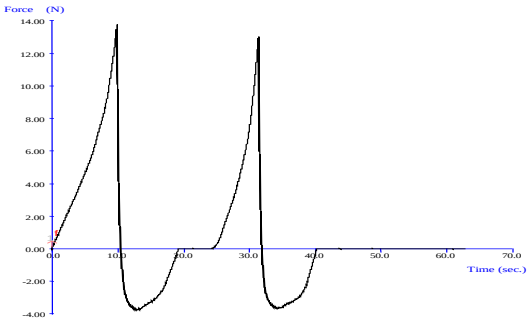


Fig 4a Interpretation of TPA graph

Source : https://texturetechnologies.com/resources/texture-profile-analysis

- **Hardness:** The highest peak force measured during first compression
- **Adhesiveness:** The negative area under the curve after the first peak
- **Cohesiveness:** The area underneath the second compression curve divided by the area underneath the first compression curve i.e. (Area 2)/(Area 1)
- **Springiness:**A ratio or percentage of a products recovery to its original height *i.e*. (Distance 2)/(Distance 1) *100
- **Gumminess**: Hardness * Cohesiveness

- **Chewiness:** Hardness * Cohesiveness * Springiness
- **Resilience:** The area under curve after peak force is reached divided by the area under curve before peak force is reached i.e. distance under Area 4/Distance 1



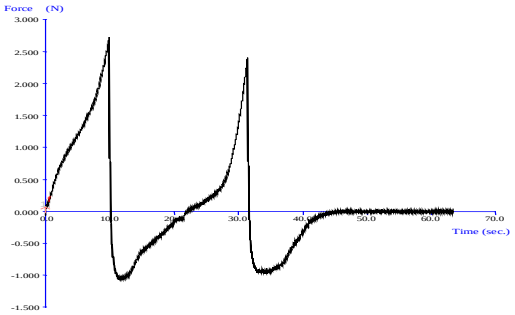


Fig 4b Pounded yam with good textural quality Pounded yam with poor textural quality

Source : Otegbayo *et al*., (2007)

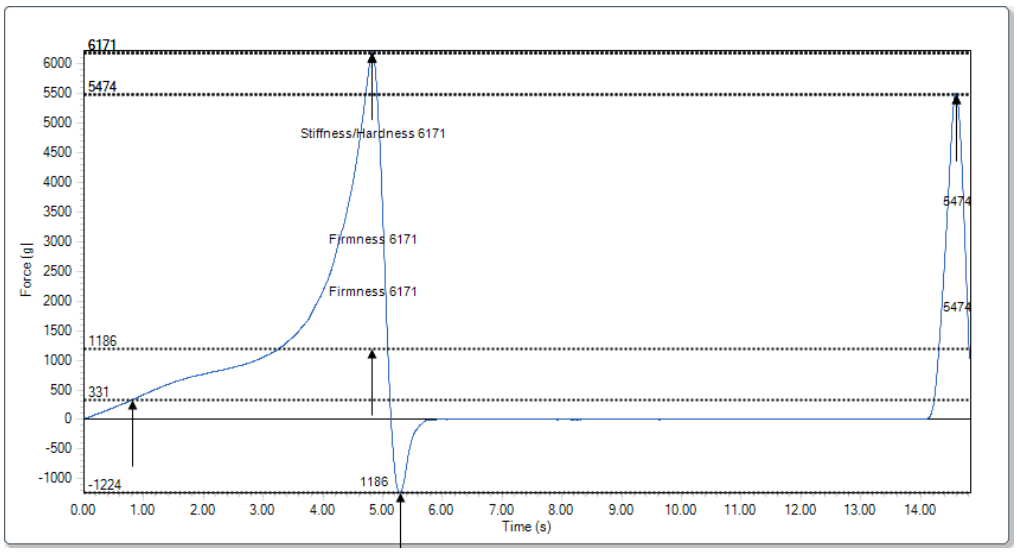


Fig. 4c TPA curve of pounded yam of good textural quality

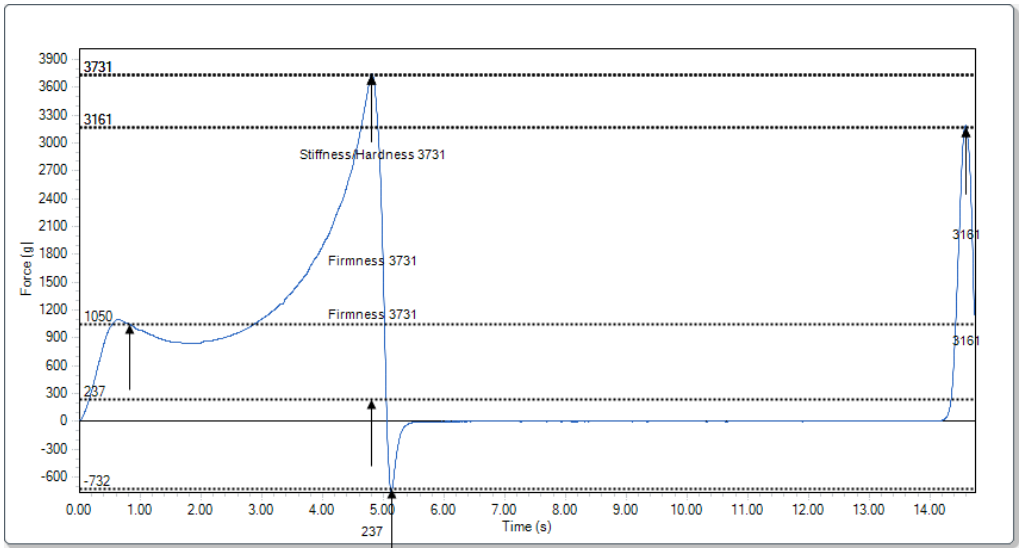


Fig. 4d TPA curve of pounded yam with poor textural quality

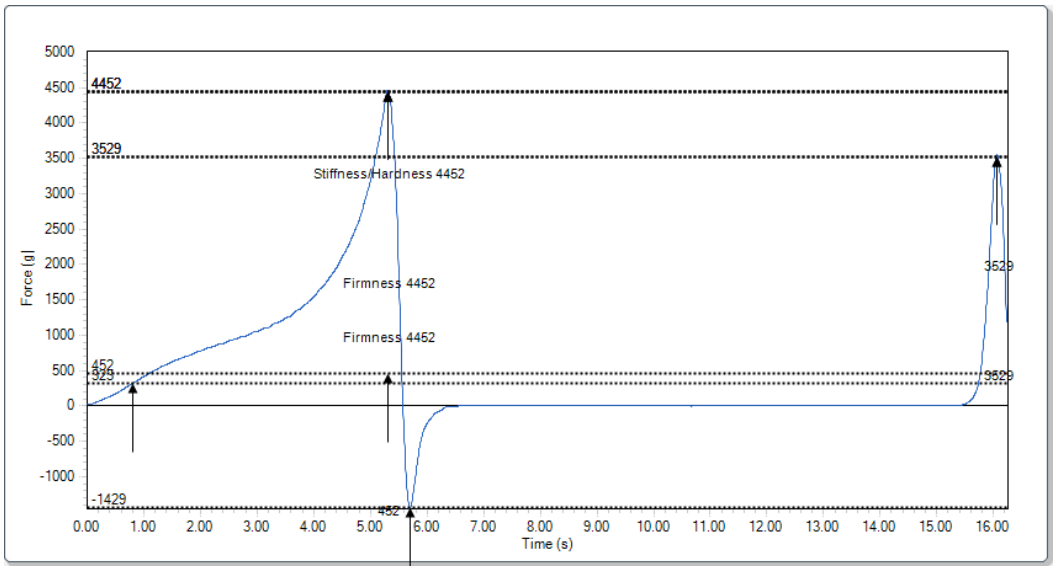


Fig 4e TPA profile of *D.alata* with good textural quality

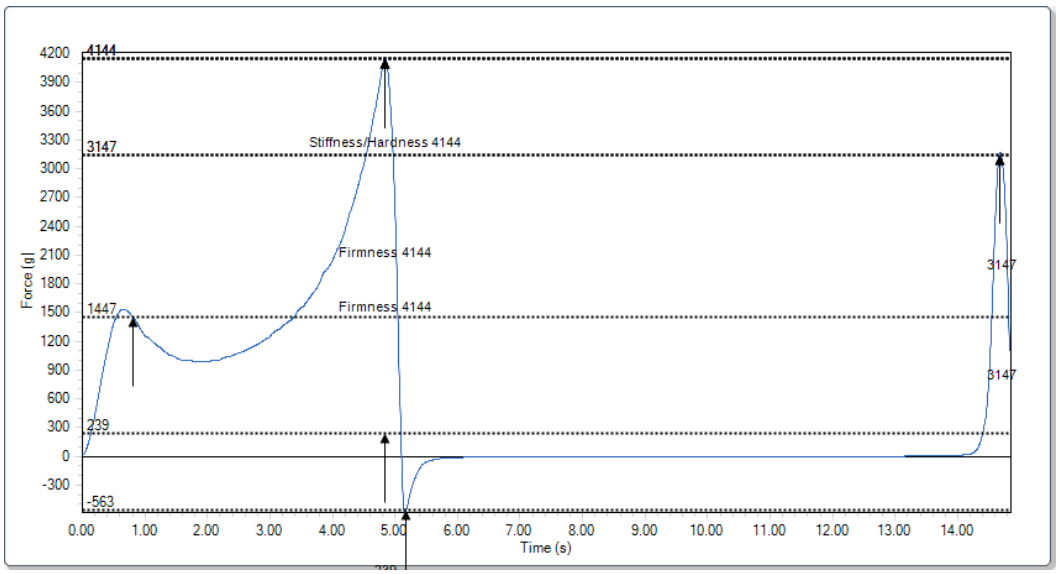


Fig 4f TPA profile of *D.alata* with poor textural quality

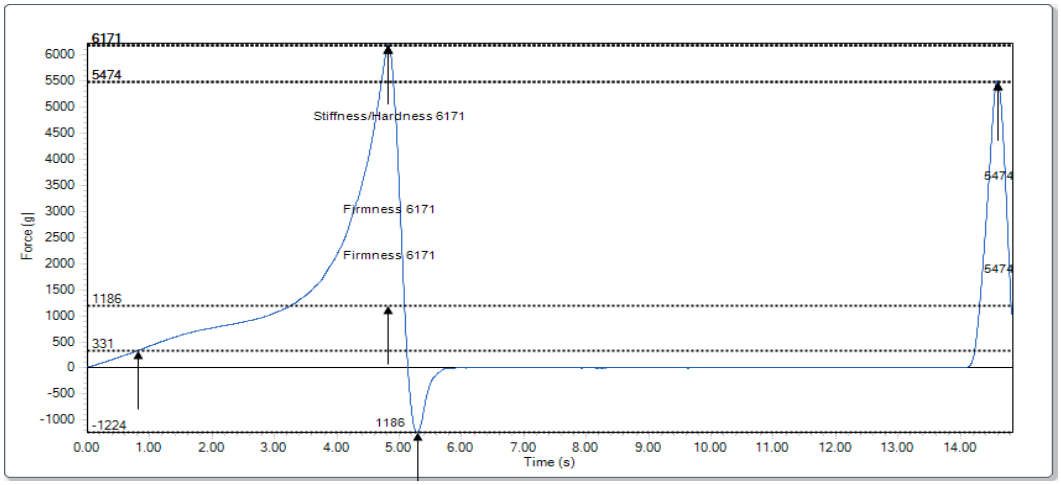


Fig 4g TPA profile of *D.rotundata* with good textural quality

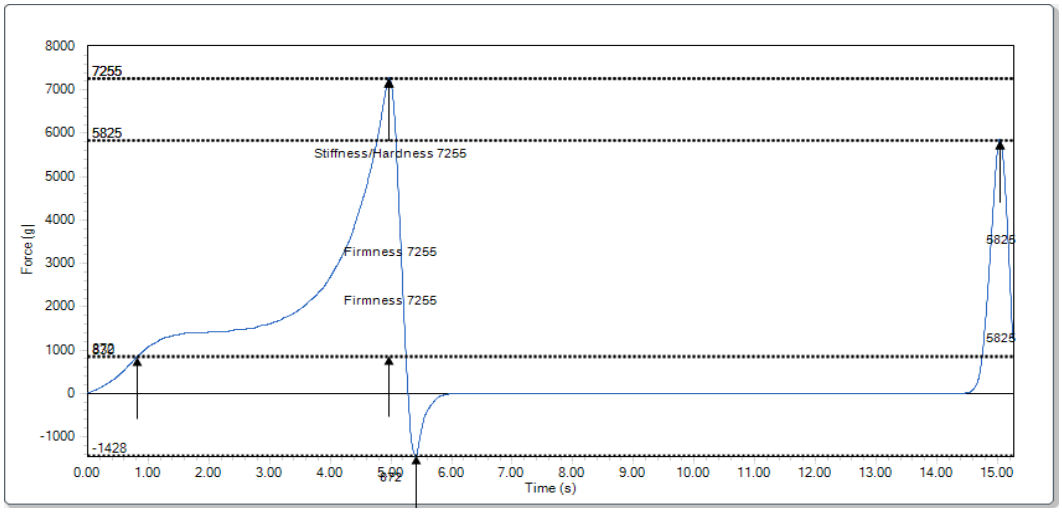


Fig 4h TPA of *D.rotundata* with poor textural quality

9 CRITICAL POINTS TO NOTE ABOUT TPA

1. The test is dimension sensitive; hence efforts should be made to ensure that the dimensions of the samples are similar to ensure results with minimum variation.
2. There should be a means of keeping the sample temperature constant to achieve minimum temperature variation amongst samples to avoid changes in textural quality as a result of temperature change. Cold samples can retrograde rapidly.
3. Each sample should be measured at least 8 - 10 times per replicate, and at least 2 cooking replicates should be considered.

10 TEST REPORT OF ITPA

An example of statistical accuracy, repeatability and discriminance of textural attributes of pounded yam made from 4 Dioscorea varieties using texture analyzer (TPA) are shown below.

Table 2 Example of statistics of textural attributes of pounded yam from 4 varieties

	Variety	Cooking replicate	N	Mean	Std Dev	Std Err	CV	Min	Max	Sum
Adhesiveness	TDr 1400158	1	14	-678.14	155.06	41.44	-22.87	-908	-320	-9494
		2	10	-1410.30	208.19	65.83	-14.76	-1804	-1165	-14103
	TDr 1401220	1	13	-849.54	267.29	74.13	-31.46	-1410	-537	-11044
		2	16	-503.88	201.83	50.46	-40.06	-905	-241	-8062
	TDr 1401593	1	15	-354.07	117.73	30.40	-33.25	-531	-116	-5311
		2	14	-339.14	140.13	37.45	-41.32	-557	-99	-4748
	TDr meccakusa	1	14	-892.64	252.46	67.47	-28.28	-1303	-469	-12497
		2	13	-974.85	353.64	98.08	-36.28	-1856	-538	-12673
Stickiness	TDr 1400158	1	14	-135.71	16.36	4.37	-12.05	-162	-102	-1900
		2	10	-128.80	14.54	4.60	-11.29	-147	-106	-1288
	TDr 1401220	1	13	-128.62	21.08	5.85	-16.39	-162	-100	-1672
		2	16	-126.75	19.03	4.76	-15.01	-169	-110	-2028
	TDr 1401593	1	15	-173.20	33.46	8.64	-19.32	-229	-99	-2598
		2	14	-165.21	35.22	9.41	-21.32	-214	-90	-2313
	TDr meccakusa	1	14	-112.86	13.01	3.48	-11.53	-132	-89	-1580
		2	13	-122.69	25.59	7.10	-20.86	-185	-94	-1595
Stiffness/Hardness	TDr 1400158	1	14	983.29	120.42	32.18	12.25	848	1269	13766
		2	10	654.10	119.35	37.74	18.25	477	822	6541
	TDr 1401220	1	13	685.23	104.32	28.93	15.22	539	837	8908
		2	16	781.56	117.87	29.47	15.08	528	973	12505

	Variety	Cooking replicate	N	Mean	Std Dev	Std Err	CV	Min	Max	Sum
	TDr 1401593	1	15	1136.07	158.11	40.82	13.92	943	1498	17041
		2	14	1103.64	109.66	29.31	9.94	920	1262	15451
	TDr meccakusa	1	14	625.21	128.35	34.30	20.53	483	914	8753
		2	13	588.08	141.89	39.35	24.13	414	838	7645
Chewiness	TDr 1400158	1	14	145.10	25.03	6.69	17.25	96.79	190.57	2031.42
		2	10	367.63	111.33	35.21	30.28	207.95	534.96	3676.31
	TDr 1401220	1	13	157.14	78.74	21.84	50.11	92.56	339.33	2042.81
		2	16	79.94	27.55	6.89	34.47	49.79	145.48	1279.07
	TDr 1401593	1	15	53.50	12.46	3.22	23.29	30.25	75.2	802.46
		2	14	45.89	10.75	2.87	23.42	28.27	62.43	642.43
	TDr meccakusa	1	14	178.67	62.60	16.73	35.04	88.74	288.45	2501.32
		2	13	178.04	84.18	23.35	47.28	88.93	337.06	2314.55
Gumminess	TDr 1400158	1	14	339.07	32.10	8.58	9.47	255	391	4747
		2	10	465.10	64.54	20.41	13.88	365	576	4651
	TDr 1401220	1	13	298.77	60.45	16.77	20.23	225	421	3884
		2	16	229.88	28.21	7.05	12.27	193	288	3678
	TDr 1401593	1	15	231.87	28.46	7.35	12.27	170	282	3478
		2	14	209.50	28.99	7.75	13.84	155	263	2933
	TDr meccakusa	1	14	313.57	42.32	11.31	13.50	243	391	4390
		2	13	305.15	75.13	20.84	24.62	226	478	3967
Cohesiveness	TDr 1400158	1	14	0.35	0.05	0.01	14.15	0.28	0.46	4.88
		2	10	0.73	0.16	0.05	21.74	0.52	1.02	7.31
	TDr 1401220	1	13	0.45	0.14	0.04	30.69	0.32	0.78	5.83
		2	16	0.30	0.08	0.02	27.70	0.22	0.54	4.87
	TDr 1401593	1	15	0.21	0.03	0.01	13.50	0.16	0.25	3.09
		2	14	0.19	0.02	0.01	11.04	0.17	0.23	2.66
	TDr meccakusa	1	14	0.53	0.15	0.04	27.68	0.32	0.80	7.36
		2	13	0.54	0.16	0.04	29.45	0.32	0.85	7.05
Springiness	TDr 1400158	1	14	0.43	0.05	0.01	11.08	0.34	0.51	5.97
		2	10	0.78	0.16	0.05	20.98	0.56	0.95	7.77
	TDr 1401220	1	13	0.50	0.14	0.04	26.81	0.35	0.81	6.56
		2	16	0.34	0.08	0.02	23.54	0.25	0.51	5.45
	TDr 1401593	1	15	0.23	0.03	0.01	12.86	0.18	0.29	3.42
		2	14	0.22	0.03	0.01	13.93	0.18	0.27	3.04
	TDr meccakusa	1	14	0.56	0.13	0.03	23.21	0.37	0.75	7.79
		2	13	0.56	0.16	0.05	29.03	0.36	0.94	7.31

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

Table 3 Example of accuracy, repeatability, and ANOVA of textural attribute (cohesiveness) of pounded yam made from 4 Dioscorea varieties

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%
TDr 1400158	24	0.5078387	0.219695	0.0448451	0.4150696	0.6006077
TDr 1401220	29	0.3691741	0.1313578	0.0243925	0.3192083	0.41914
TDr 1401593	29	0.1983866	0.0257041	0.0047731	0.1886093	0.2081639
TDr meccakusa	27	0.5334735	0.1496997	0.0288097	0.4742542	0.5926927

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

By Variety

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

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

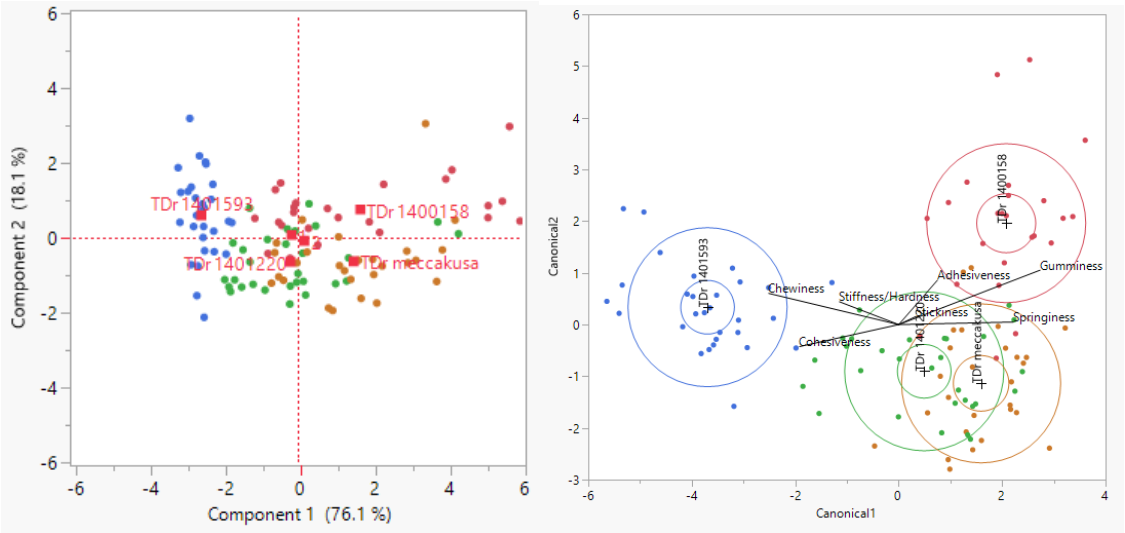


Fig 5 Principal component and Discriminant analysis of pounded yam texture of 4 varieties of yam

Table 4 Example of values for mean instrumental textural attributes of pounded yam from 13 *D.alata* and *D.rotundata* yams

Varieties	Stiffness/ Hardness	Adhesiveness (g.mm)	Stickiness (g)	Stringiness (mm)	Resilience	Cohesiveness	Springiness
TDr1401593	7177.8b	-1165.5b	-1023.2bc	0.995a	0.045b	0.121a	0.995a
TDr1000048	6734.4b	-1512.6bc	-1383.1d	0.935abc	0.027c	0.117a	0.935abc
TDr1400359	4356.8a	-1305.1b	-904.3b	0.765c	0.01d	0.13a	0.765c
TDr0900067	6397.2b	-1832.6c	-1180.8cd	0.953ab	0.028c	0.176b	0.953ab
TDr1100180	8961.8a	-436.0a	-579.8a	0.971a	0.066a	0.128a	0.971a
TDr1401419	6397.8b	-2917.1d	-1722.3e	0.988a	-0.008e	0.178b	0.988a
IGN	5090.6a	-1919.5c	-1230.2cd	0.788bc	0.003de	0.198a	0.788bc
Mean	6445.2	-1584.1	-1146.2	0.914	0.024	0.150	0.914
SE	559.65	289.80	137.21	0.04	0.01	0.01	0.04
TDa1400301	5796.1^{a}	-731.1^{a}	-1041.6^{b}	0.911^{a}	0.03^{a}	0.078b^{c}	0.911^{a}
TDa1100224	3561.8^{a}	-732.6^{a}	-530.4^{a}	0.953^{a}	0.01ab	0.061^{c}	0.953^{a}
TDa1215201	4694.3^{bc}	-1361.5^{bc}	-1102.1^{b}	0.965^{a}	0.014^{ab}	0.131^{a}	0.965^{a}
TDa1100432	4187.8^{b}	-973.6^{ab}	-1010.2^{b}	0.992^{a}	0.01^{ab}	0.088^{b}	0.992^{a}
TDa1100201	4985.5^{b}	-1692.7^{c}	-1339.6^{c}	0.995^{a}	-0.005^{bc}	0.079^{bc}	0.995^{a}
TDa1100316	4969.6^{b}	-2482.4^{d}	-1411.9^{c}	0.967^{a}	-0.024^{c}	0.126^{a}	0.967^{a}
Mean	4699.2	-1329.0	-1072.6	0.964	0.006	0.094	0.964
SE	311.6	277.1	127.3	0.012	0.008	0.012	0.012

10.1 Correlation between sensory and instrumental textural quality attributes of pounded yam

The correlation coefficients (r) and correlation probabilities (P) between the ITPA parameters and ITPA versus STPA parameters of pounded yam samples are presented in Table 5 & Table 6 respectively, for the *Dioscorea* varieties combined.

Table 5 Correlation coefficients of sensory and instrumental attributes of pounded yam made from combined data of *D. alata* and *D. rotundata*

Instrument	*Sensory*				*Instrumental*						
	Adhesiveness	***Moudability***	***Stretchability***	***Hardness***	*Hardness*	*Adhesiveness*	*Stickiness*	*Stringiness*	*Resilience*	*Cohesiveness*	*Springiness*
Hardness	-0.498	0.507	0.257	0.165	1						
Adhesiveness	0.173	-0.347	-0.471	-0.048	0.065	1					
Stickiness	0.337	-0.193	-0.304	-0.318	-0.044	0.863	1				
Stringiness	-0.320	-0.390	-0.522	0.423	0.202	-0.065	-0.147	1			
Resilience	-0.094	0.213	-0.022	-0.138	0.665	0.735	0.593	-0.006	1		
Cohesiveness	0.010	0.839	0.907	-0.315	0.307	-0.645	-0.451	-0.302	-0.124	1	
Springiness	-0.320	-0.390	-0.522	0.423	0.202	-0.065	-0.147	1	-0.006	-0.302	1

Table 6 Correlation probabilities of sensory and instrumental attributes of pounded yam made from combined data of *D. alata* and *D. rotundata*

Instrument	***Sensory***				***Instrumental***						
	Adhesiveness	***Moudability***	***Stretchability***	***Hardness***	*Hardness*	*Adhesiveness*	*Stickiness*	*Stringiness*	*Resilience*	*Cohesiveness*	*Springiness*
Hardness	0.084	0.077	0.397	0.590	<0.0001						
Adhesiveness	0.572	0.246	0.104	0.867	0.832	<0.0001					
Stickiness	0.260	0.527	0.312	0.290	0.887	**0.0001**	<0.0001				
Stringiness	0.286	0.188	0.067	0.149	0.508	0.833	0.632	<0.0001			
Resilience	0.761	0.484	0.943	0.653	**0.013**	**0.0042**	**0.033**	0.983	<0.0001		
Cohesiveness	0.975	**0.0003**	**<0.0001**	0.295	0.308	**0.017**	0.121	0.316	0.687	<0.0001	
Springiness	0.286	0.188	0.067	0.149	0.508	0.833	0.632	**<0.0001**	0.983	0.316	<0.0001

(Red highlighted correlation probabilities are significant at 5 % level

The following relationships had significant correlation probabilities at 5% significance level:

Instrumental adhesiveness and instrumental stickiness (P = 0.0001)

Instrumental resilience and instrumental hardness (P = 0.013)

Instrumental resilience and instrumental adhesiveness (P = 0.0042)

Instrumental resilience and instrumental stickiness (P = 0.033)

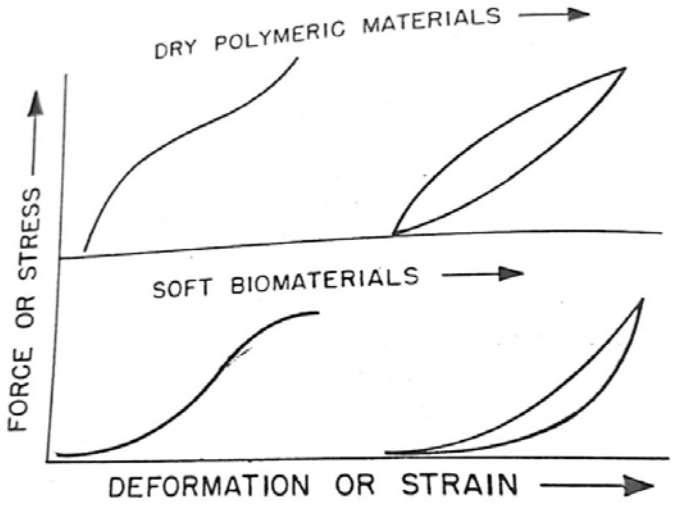
Instrumental cohesiveness and sensory mouldability (P = 0.0003)

Instrumental cohesiveness and sensory stretchability (P <0.0001)

The only significant correlations existing between sensory and instrumental textural attributes were instrumental cohesiveness and sensory mouldability (P = 0.0003) and instrumental cohesiveness and sensory stretchability (P <0.0001).

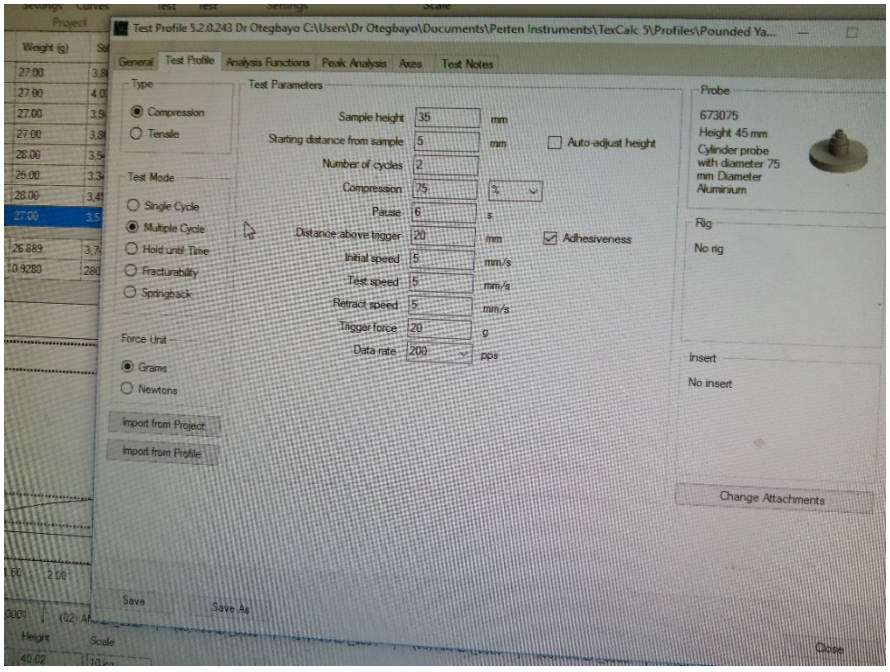
11 APPENDICES

11.1 Annex 1 Force-deformation curves of Polymeric materials and soft biological materials.



Source: Mohsenin (1986)

11.2 Annex 2 Setting of Test Profile on the TVT



+ Credits for each Picture.

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