Laboratory Standard Operating Procedure

Standard Operating Protocol for Textural Characterization of Fufu

Biophysical Characterization of Quality Traits, WP2

Umudike, Nigeria, 2022

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Standard Operating Protocol for Textural Characterization of Fufu	
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ABSTRACT

Fufu is one of the popular fermented products processed from cassava roots and it is widely consumed in Nigeria and other West African countries. This study was carried out to establish the textural profile of fufu processed from four (4) different cultivars of cassava. Smooth texture, among other attributes, is closely associated with fufu of good quality and this varies with processors, season and variety. Therefore, it is of importance to standardize the processing, preparation and instrumental textural profile of fufu as these aids in selection, preference and overall acceptability of the product and cassava variety by end users. The processing and preparation of fufu used for the development of this standard operating procedure (SOP) was carried out following the RTBfoods harmonized SOP for sensory characteristics of fufu. This SOP encapsulates the materials required for the standardized preparations, processing, and instrumental textural profile analysis of fufu in the laboratory. It also includes the calibrations and operations of the texture analyser used for the measurements, interpretation and calculation of texture parameters and the critical points such as the temperature control, replications of the measurements and uniform dimension for samples presentation. Generally, the SOP includes instrumental measurement of texture attributes of fufu such as hardness, adhesiveness, cohesiveness, springiness, gumminess, chewiness and resilience using a texture analyser. A double compression mode was considered for the procedure. Two sets of replicate measurements were made for a fixed cylindrical sample geometry (40 mm x 47 mm) at 45°C, and a combination of measurement parameters (pre-test speed 1mm/s, test speed 2 mm/s, strain 30%, compression cycle interlude 10 s, compression probe 100 mm diameter). Statistical analyses of the data obtained can assist to determine the validity of the procedure for texture measurement by evaluating if reproducibility between replicate measurements and discrimination between various cassava genotypes is possible based on their inherent textural character.

Key Words: Fufu, Cassava, Texture, SOP, Fermentation, Quality traits, Textural Profile Analysis

1 SCOPE AND APPLICATION

The objective of the study is to establish a standard operating procedure (SOP) for measuring *fufu* texture using a texture analyser. This SOP describes the procedures involved in preparation of *fufu* samples for texture analysis and the interpretation and calculation of textural parameters associated with fufu.

2 REFERENCES

Adeoti, O., Ayelegun, T., Oyewole, B. (2009). Impact of gari consumption on the water resource of Nigeria. *African Journal of Biotechnology*: 8(25).

Akingbala, J.O., Oguntimein, G.B., & Abass, A.B. (1991). Effect of processing methods on the quality and acceptability of fufu from low cyanide cassava. *J Sci Food Agric* 57:151–154

Bourne, M. (2002). Food Texture and Viscosity. San Diego: Academic Press

Obilie, E., Tano-Debrah, K., and Amoa-Awua, W. (2003). Microbial modification of the texture of grated Cassava during fermentation into akyeke. *International Journal of Food Microbiology* 89, 275-280

Oyewole, O.B., & Sanni, L.O. (1995). Constraints in traditional cassava processing: the case of 'fufu' production, in *Cassava Food Processing*, ed. by Agbor Egbe T, Brauman A, Griffon T and Treche S. ORSTOM, Paris, pp. 523–529

Rodriguez-Sandoval, E., Fernández-Quintero, A., Sandoval-Aldana, A. and Cuvelier, G. (2008). Effect of Processing Conditions on the texture of reconstituted cassava dough. *Brazilian Journal of Chemical Engineering* 25 (4), 713-722.

Sanni, L.O., Akingbala, J.O., Oguntunde, A.O., Bainbridge, Z.A., Graffham, A.J & Westby, A. (1998). Processing of fufu from cassava in Nigeria: problems and prospects for development. *Sci Technol Dev* 16:58–71

Singh, V., Guizani, N., Al-Alawi, A., Claereboudt, M. and Rahman, M. (2013). Instrumental Texture Profile Analysis (TPA) of Date fruits as a function of its physico-chemical properties. *Industrial Crops and Products* 50, 866-873

Tomlins, K., Sanni, L., Oyewole, O., Dipeolu, A., Ayinde, I., Adebayo, K., & Westby, A. (2007). Consumer acceptability and sensory evaluation of a fermented cassava product (Nigerian fufu). *Journal of the Science of Food and Agriculture* 87:1949–1956

3 DEFINITIONS

Textural attributes associated with fufu quality which are of interest include the following:

Adhesiveness: According to Singh et al. (2013), adhesiveness can be defined as the work required in overcoming the attractive force between a product and the contact surface.

Cohesiveness: Rodriguez-Sandoval et al. (2008), defined cohesiveness as the direct work required to overcome the internal bonds of a material.

Hardness: According to Bourne (2002), hardness is the maximum force required to compress a sample.

Springiness: Springiness is a sample's ability to return to its original state after it has been deformed during the first compression and has been allowed to wait for the interval between strokes.

4 PRINCIPLE

Fufu is one of the popular fermented products processed from cassava roots. It is widely consumed in Nigeria and other West African countries and it is considered one of the main sources of carbohydrate in the Nigerian diet (Adeoti et al. 2009). Preparation of fufu involves: fermentation of the fresh cassava roots for a period of 72 hours to obtain an intermediate fermented product, and cooking of the intermediate wet fufu mash into a final dough-like product called *fufu*. Obilie et al. (2003) noted that one of the reasons for fermenting cassava roots is to optimize the texture of cassava fermented products, thereby improving sensory characteristics. Flavour, appearance and texture are widely recognized as significant factors that determine fufu acceptance and quality (Tomlins et al. 2007). Fufu is considered by consumers to be of good quality when it has a smooth texture, among other characteristics (Akingbala et al. 1991). The quality of fufu, however, varies with processors and season (Oyewole and Sanni, 1995) and this variability has been attributed to various local practices by the processors (Sanni et al, 1998). The method of cooking fufu which involves constant stirring of the reconstituted fufu paste with continuous supply of heat for about 5 minutes as contained in RTBfoods harmonized SOP was adopted during the development of this SOP.

5 APPARATUS

- Texture analyser with load cell able to measure maximum force of 100kg (the model used for the development of this SOP is a TA-XT.Plus, Stable Microsystems).
- Weighing balance
- Gas cooker as a source of heat
- Cooking pots
- Stainless bowl
- Measuring cylinder
- Wooden stirrer
- Infrared thermometer to monitor the temperature of the samples
- Stop watch to record stirring and cooking time
- Cylindrical sampling cup (4.0 cm long x 4.7 cm diameter)
- Styrofoam food warmer

Using and managing a texture analyser: The Stable Microsystems TA. XT plus Texture analyzer (Serial No: 41939) is equipped with a 5 kg load cell, keypad and a personal computer. The instrument is kept in a cool, dry room, on a level surface with no vibrating instruments in proximity. All necessary cables are connected to a power supply before starting the analysis, and the equipment can warm up for at least 15 minutes. A force calibration is done using a 2 kg standard weight, while calibration of probe distance is done afterwards. During the analysis, no contact must be made with the probe and platform area (to avoid injuries). The red stop button on the bottom right side of the instrument is pressed in the event of any emergency. After the analysis, the platform and probes are cleaned with a moist, soft cloth, and often with ethanol to avoid staining or removal of sample residues on platform.

6 PROCEDURE

6.1 Sampling and intermediate product preparation in laboratory conditions

- ✓ Sampling and intermediate product preparation was carried out following RTBfoods harmonized SOP for sensory characterization of fufu.

6.2 Final product preparation (cooking of intermediate product (dewatered fufu mash)

- ✓ About 250g of the dewatered fermented fufu mash (dry matter content of 44 %) of each sample is weighed into clean and dry bowl

Figure 1: Weighing fufu mash into a plastic bowl

- ✓ 175ml of clean water is measured and poured into the weighed mash and using the finger tips, it is mixed thoroughly to form a uniform thick paste

  Note: (250g of fufu mash in 175ml of water is same ratio as with 100g of fufu mash in 70ml of water as established in RTBfoods Harmonised SOP for Sensory characterization of fufu. The increase in mass is to produce enough dough needed for the 10 replications required in the development of this SOP)

- ✓ The paste is transferred into a clean cooking pot and placed on heat supplied directly to the pot. The heat is supplied from gas combustion from a gas cylinder with flow control.
- ✓ It is allowed to pre-gelatinise for about 60 seconds undisturbed/ without stiring (the timing started immediately the cooking pot is placed on heat; generally initial gelling temperature is about 40 ^{o}C).
- ✓ While still on heat, the cooking pot is held firmly with one hand and the pre-gelled mash is stirred continously with the other hand using a wooden stirrer for about 4 minutes until a creamy-white homogenous stiff dough is formed at a final cooking temperature of about 80 ^{o}C. Total cooking time is about 5 minutes.

Figure 2: **Cooking of the fufu paste into a dough**

- ✓ The heat is put off and the cooked fufu was immediately scooped into a food grade polythene, wrapped and placed in a styrofoam food warmer to reduce temperature decline. The sample is stored briefly between 5 – 10 min before measurements. The temperature was monitored using an infrared thermometer before texture analysis.

Figure 3: Fufu wrapped with food grade polythene and kept in a styrofoam warmer.

- ✓ A cylindrical open-end plastic cup with dimension of 4.0 cm long x 4.7 cm diameter was adapted for moulding the sample to obtain uniform sample dimension and shape. The measurements were taken in batches immediately after the sample is shaped, removed from the mould, and allowed to cool to a temperature of 45°C.

Figure 4: Cylindrical cup (4.0 cm long x 4.7 cm diameter) for sample preparation

Important points to note:

- Each sample is prepared in duplicate and a total of ten (10) measurements are taken for each variety.

- Samples are wrapped in food grade packaging polyethene and transferred into a styrofoam warmer to maintain temperature and minimize physical changes that could arise due to rapid cooling.
- Sample temperature was monitored using an infra-red thermometer.

Figure 5: Monitoring of sample temperature using infra-red thermometer

- Similar sample preparation procedures and temperature of 45°C are used for both instrumental and sensory analysis.

6.3 Texture measurement

Equipment: TA.XT Plus Texture Analyzer, Serial Number 41939 (Stable Microsystems, London)

Method: Double compression using 100 mm diameter cylindrical compression plate

Pre-test speed	**1 mm/s**
Post-test speed	**5 mm/s**
Time between compression strokes	**10 s**
Test speed	**2 mm/s**
Trigger force (when the probe touches the surface of the sample)	**10 g**
Strain	**30 %**
Temperature of test	**45 °C**

- ✓ The Textural Profile Analysis (TPA) of fufu was measured using a Stable Microsystems TA. XT plus equipped with standard compression cylindrical plate of 100 mm diameter
- ✓ The texture analyser was switched on using the main switch located at the rear end and the PC was connected appropriately.
- ✓ TPA test settings was selected from the library and a project folder was created to recover analysis data.
- ✓ The probe height and force were calibrated following the instructions in the operation manual.

- ✓ Sample of uniform dimension 4.0 cm height x 4.7 cm diameter was placed at the centre of the instrument platform after a temperature of 45°C was reached.

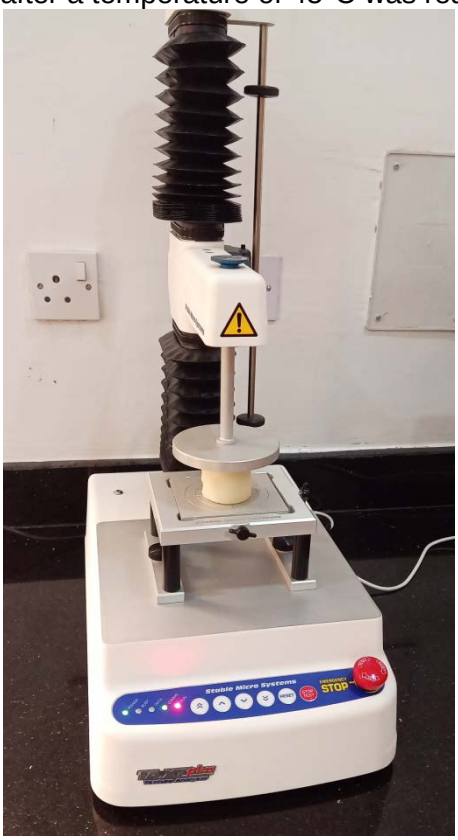


Figure 6: Sample placed on the platform for analysis

- ✓ The analysis was initiated by clicking the *Run* button on the instrument software
- ✓ Double compression of the samples was done automatically with a 10g trigger force and 10 seconds interval between each compressions.

7 EXPRESSION OF RESULTS

The figure below is a schematic diagram explaining a TPA profile. A TPA test generally follows a standard sequence.

- ✓ **1st compression:** the probe descends onto the sample, once contact is made, measurement begins and the probe descends at a defined speed, for a set distance or a set time.

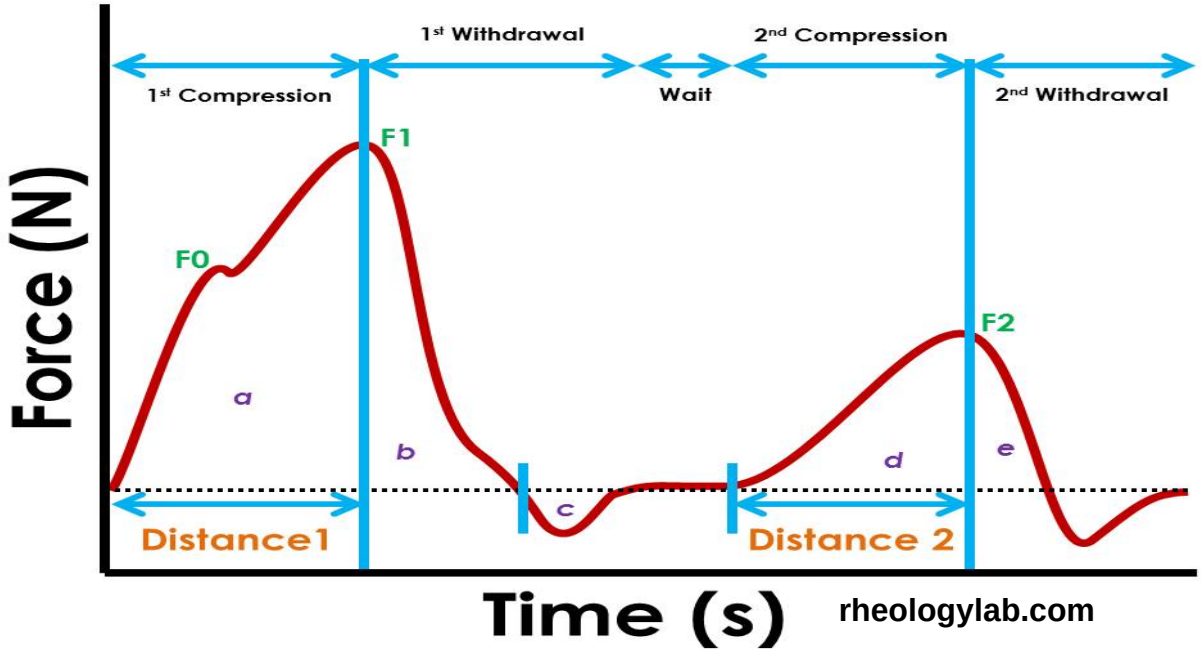


Figure 7: A graph showing the calculation of TPA parameters

- ✓ **1st withdrawal:** Once the target distance/time is reached, the probe ascends away from the sample at a typically faster speed for a set distance or a set time.
- ✓ **Wait:** The sample can be allowed to recover before the process is repeated.
- ✓ **2nd compression and 2nd withdrawal :** After the waiting time, a second cycle of compresssion and withdrawal occurs

7.1 Summary of parameters from texture profile analysis

- ➢ **Hardness (g) :** The highest peak force measured during first compression **(F1)**.
- ➢ **Adhesiveness (g·s) :** The area covered by the first negative peak **(c)**.
- ➢ **Cohesiveness (-) :** The area underneath the second compression curve divided by the area underneath the first compression curve (**(d+e)/(a+b)**).
- ➢ **Springiness (%) :** A ratio or percentage of a product's recovery to its original height (**(Distance 2)/(Distance 1)*100** or **(Time 2/Time 1)*100**).
- ➢ **Gumminess (g) :** Hardness x Cohesiveness **(F1*((d+e)/(a+b)))**.
- ➢ **Chewiness (g) :** Hardness x Cohesiveness x Springiness (**F1*(Distance 2/Distance 1)*(d+e)/(a+b)**).
- ➢ **Resilience :** The area under curve after peak force is reached divided by the area under curve before peak force is reached **(b/a)**.

8 CRITICAL POINTS OR NOTE ON THE PROCEDURE

- ❖ Analysis of the sample needs to be done quickly as the texture of fufu changes with time especially when cooling.
- ❖ The same serving temperature must be maintained for both instrumental and sensory analysis.

- ❖ The trigger force of compression probe must be carefully adjusted to forestall the total collapse of the sample at the first compression cycle.
- ❖ The sensory and instrumental texture analysis must be conducted simultaneously for the excellent correlation of sensory and instrumental results.
- ❖ Each sample must be replicated to obtain a true representative.

9 APPENDICES

9.1 Example of data on *fufu* instrumental textural profile analysis

Varieties:

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

Procedure

Texture measurements using the texture analyser (TPA method) was carried out by preparing fufu based on the SOP for fufu preparation and was used with no modifications. Two preparations or cooking replicates per variety was considered. Five measurements per cooking replicate was collected.

Statistical accuracy of texture attributes

	variety	cooking replicate	N	Mean	Std Err	CV (%)
Hardness (g)	518	1	5	608.6	23.9	8.8
		2	5	655.3	18.2	6.2
	1368	1	5	2097.6	78.7	8.4
		2	5	1883.0	66.2	7.9
	chenke	1	5	840.5	20.0	5.3
		2	5	874.0	12.5	3.2
	wonono	1	5	1070.9	12.9	2.7
		2	5	1026.2	24.0	5.2
Adhesiveness (g·s)	518	1	5	-350.1	50.5	-32.3
		2	5	-334.4	32.6	-21.8
	1368	1	5	-454.9	188.6	-92.7
		2	5	-487.9	207.4	-95.0
	chenke	1	5	-156.2	12.3	-17.6
		2	5	-149.7	12.3	-18.4
	wonono	1	5	-209.5	32.8	-35.0
		2	5	-239.7	12.7	-11.8
Springiness (-)	518	1	5	0.499	0.030	13.2
		2	5	0.457	0.012	6.0
	1368	1	5	0.399	0.036	20.4
		2	5	0.346	0.010	6.1
	chenke	1	5	0.432	0.139	72.0
		2	5	0.312	0.011	7.7

	variety	cooking replicate	N	Mean	Std Err	CV (%)
	wonono	1	5	0.348	0.015	9.8
		2	5	0.345	0.007	4.7
Cohesiveness (-)	518	1	5	0.403	0.0127	7.1
		2	5	0.405	0.0061	3.4
	1368	1	5	0.326	0.0080	5.5
		2	5	0.340	0.0048	3.2
	chenke	1	5	0.288	0.0065	5.0
		2	5	0.299	0.0051	3.8
	wonono	1	5	0.323	0.0090	6.2
		2	5	0.332	0.0072	4.9
Gumminess (g)	518	1	5	244.555	7.730	7.1
		2	5	265.421	7.237	6.1
	1368	1	5	685.438	37.328	12.2
		2	5	639.340	20.746	7.3
	chenke	1	5	241.416	3.788	3.5
		2	5	261.327	4.865	4.2
	wonono	1	5	345.580	11.253	7.3
		2	5	340.289	5.067	3.3
Chewiness (-)	518	1	5	122.450	9.017	16.5
		2	5	121.501	5.848	10.8
	1368	1	5	274.691	29.923	24.4
		2	5	221.705	10.634	10.7
	chenke	1	5	105.136	34.907	74.2
		2	5	81.316	1.159	3.2
	wonono	1	5	120.758	9.427	17.5
		2	5	117.475	3.911	7.4
Resilience (-)	518	1	5	0.087	0.002	6.2
		2	5	0.089	0.002	4.0
	1368	1	5	0.103	0.002	4.8
		2	5	0.107	0.002	4.3
	chenke	1	5	0.069	0.000	1.2
		2	5	0.075	0.001	4.4
	wonono	1	5	0.082	0.002	4.9
		2	5	0.081	0.002	6.2

Example of ANOVA and Repeatability of textural parameters

Hardness

By Variety

Analysis of Variance

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

By cooking replicate

Analysis of Variance

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

Means and Std Deviations

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

Connecting Letters Report

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

Levels not connected by same letter are significantly different.

Ordered Differences Report

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

Means and Std Deviations

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

Connecting Letters Report

Level		Mean
1	A	1154.3914
2	A	1109.6141

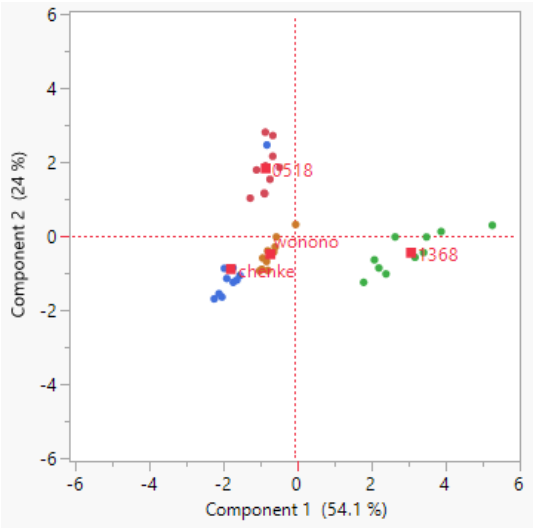
Levels not connected by same letter are significantly different.

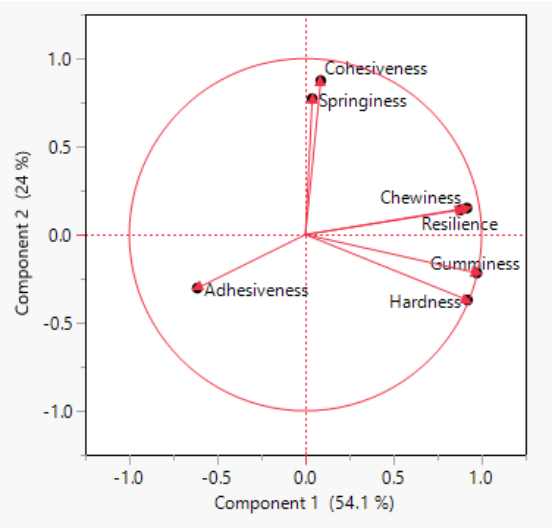
Ordered Differences Report

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

The textural parameters for the varieties generally showed good repeatability with no significant differences between the replicate means. ANOVA reveals the textural parameters of the varieties were significantly different from one another.

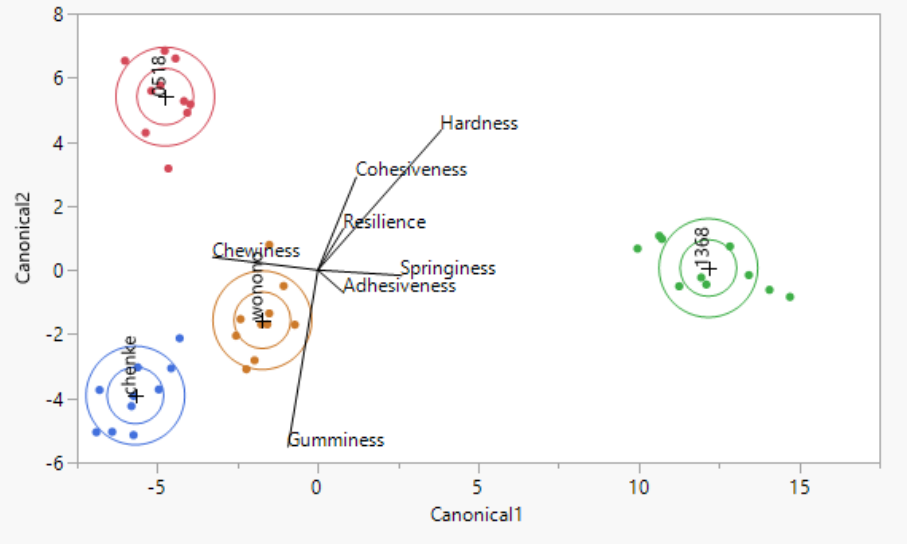
Discriminance between varieties based on textural profile





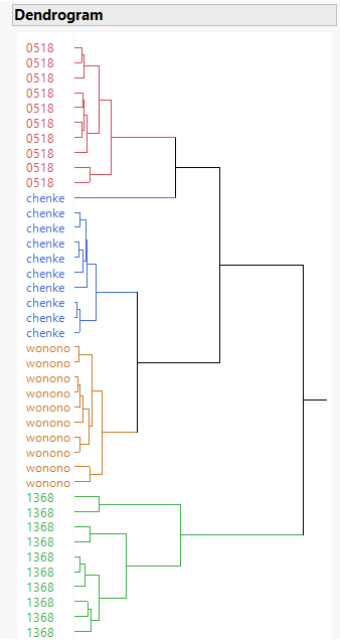
PCA

The first two components of the PCA explained 78.1 % of the variation. Varieties are distinctly grouped in separate component spaces. All the textural attributes contribute significantly to the components except adhesiveness.



Discriminance

The varieties are uniquely discriminated as shown in separate canonical spaces. All the textural attributes are of particular importance in discriminating between the varieties, except adhesiveness.



Hierarchical classes

The varieties were uniquely classified into 4 groups in the hierarchical class, showing good discrimination based on the textural properties.

Summary

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

Conclusion

TPA may be conducted with a texture analyser in determining discriminant character of textural attributes of fufu made from various cassava genotypes.

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