Review on pounded yam extensibility texture of 138 genotypes analysed by Kieffer dough extensibility at CNRA, Côte d'Ivoire

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Abstract

The CNRA yam genetic resources collection contains a diversity of accessions consisting of traditional, introduced and hybrid varieties. This collection was subjected to characterization of the quality of pounded yam (foutou) by texture in order to identify varieties suitable for making pounded yam. The instrumental texture parameters measured are the extensogram peak force (N), extensibility (mm), and extension area (N.mm). The results show that the measured parameters are positively and strongly correlated. Among these parameters, the extension area (N.mm) best discriminates among the genotypes while the extensibility (mm) best discriminates between the two species (*alata* and *rotundata*). PCA coupled with ascending hierarchical classification (ACH) made it possible to screen the varieties into three classes taking into account their extensibility, that is to say their ability to make pounded yam that extends in texture. Class 1 consists of 10 varieties with high extensibility. The varieties in this class, all of them of *D. rotundata* species, are capable of making good pounded yam and can therefore be selected as priority genotypes. Class 2 includes 21 varieties with medium extensibility. The varieties in this class, which include both *D. rotundata* and *D. alata* varieties, can make pounded yam of medium quality. Class 3 includes few varieties of *D. rotundata*, and most of the *D. alata* varieties of have low extensibility and cannot produce good quality pounded yam (foutou).

Key-words: pounded yam, *D. rotundata*, *D. alata*, extensogram peak force, extensibility, extension area

1 INTRODUCTION

Yam is Cote d'Ivoire's leading food crop, with a production of over 8 million tons (Faostat, 2023). The country has a diversity of traditional varieties, most of which are conserved in the genetic resources collection of the National Center for Agricultural Research (CNRA). This collection also contains introduced varieties as well as hybrids selected by the CNRA. In Côte d'Ivoire, yam is eaten boiled, stewed, braised, fried, and especially in the form of foutou (pounded yam). The collection held by the CNRA is regularly subject to agronomic and morphological characterization in order to study the diversity that exists there. However, the lack of knowledge on the quality of pounded yam in the collection constitutes a constraint to selection. In the case of the RTB Breeding project, emphasis was placed on characterizing the quality of this collection. The aim was therefore to characterize the CNRA yam collection in relation to the extensibility of pounded yam using the Kieffer dough extensibility method following a SOP developed by the project. This report describes the screening of the 138 genotypes in the CNRA yam collection for their suitability for making pounded yam.

2 MATERIAL AND METHODOLOGY

2.1 Vegetal material

The plant materials consisted of 138 yam genotypes, including 67 *D. alata* and 71 *D. rotundata*. These varieties included traditional varieties (landraces) and improved varieties from IITA and CNRA. The Table 1 below shows the varieties used for the tests.

Table 1 Yam genotypes used to the characterisation of KDGE extensibility

N°	Specie	Varieties	Kind of variety	N°	Specie	Varieties	Kind of variety
1	D.alata	CNRAIGA 1900060	hybrid	1	D.rotundata	ALLUSHI	hybrid
2	D.alata	CIVCDA 008	traditional	2	D.rotundata	CIVCDR	CIVCDR
3	D.alata	CIVCDA 02000107	traditional	3	D.rotundata	CIVCDR 015	improved
4	D.alata	CIVCDA 050	traditional	4	D.rotundata	CIVCDR 026	traditional
5	D.alata	CIVCDA 05000107	traditional	5	D.rotundata	CIVCDR 052	hybrid
6	D.alata	CIVCDA 065	traditional	6	D.rotundata	CIVCDR 055	hybrid
7	D.alata	CIVCDA 076	traditional	7	D.rotundata	CIVCDR 058	hybrid
8	D.alata	CIVCDA 088	traditional	8	D.rotundata	CIVCDR 060	hybrid
9	D.alata	CIVCDA 101	traditional	9	D.rotundata	CIVCDR 064	hybrid
10	D.alata	CIVCDA 114	hybrid	10	D.rotundata	CIVCDR 065	hybrid
11	D.alata	CIVCDA 117	hybrid	11	D.rotundata	CIVCDR 068	hybrid
12	D.alata	CIVCDA 119	hybrid	12	D.rotundata	CIVCDR 072	hybrid
13	D.alata	CIVCDA 120	hybrid	13	D.rotundata	CIVCDR 074	hybrid
14	D.alata	CIVCDA 121	hybrid	14	D.rotundata	CIVCDR 079	hybrid
15	D.alata	CIVCDA 122	hybrid	15	D.rotundata	CIVCDR 082	hybrid
16	D.alata	CIVCDA 124	hybrid	16	D.rotundata	CIVCDR 088	hybrid
17	D.alata	CIVCDA 130	hybrid	17	D.rotundata	CIVCDR 096	hybrid
18	D.alata	CIVCDA 133	hybrid	18	D.rotundata	CIVCDR 101	hybrid
19	D.alata	CIVCDA 151	hybrid	19	D.rotundata	CIVCDR 104	hybrid

20	D.alata	CIVCDA 155	hybrid	20	D.rotundata	CIVCDR 116	hybrid
21	D.alata	CIVCDA 190	hybrid	21	D.rotundata	CIVCDR 117	hybrid
22	D.alata	CIVCDA 218	traditional	22	D.rotundata	CIVCDR 150	traditional
23	D.alata	CIVCDA 228	traditional	23	D.rotundata	CIVCDR 200	traditional
24	D.alata	CIVCDA 328	traditional	24	D.rotundata	CIVCDR 268	traditional
25	D.alata	CIVCDA 354	traditional	25	D.rotundata	CIVCDR 368	traditional
26	D.alata	CIVCDA 356	traditional	26	D.rotundata	CIVCDR 423	traditional
27	D.alata	CIVCDA 382	traditional	27	D.rotundata	CIVCDR 440	traditional
28	D.alata	CIVCDA 402	traditional	28	D.rotundata	CIVCDR 450	traditional
29	D.alata	CIVCDA 403	traditional	29	D.rotundata	CIVCDR 451	traditional
30	D.alata	CNRAIGA 1900122	hybrid	30	D.rotundata	CIVCDR 452	traditional
31	D.alata	CNRAIGA 1500028	hybrid	31	D.rotundata	CIVCDR 455	traditional
32	D.alata	CNRAIGA 1900035	hybrid	32	D.rotundata	CIVCDR 458	traditional
33	D.alata	CNRAIGA 1900039	hybrid	33	D.rotundata	CIVCDR 464	traditional
34	D.alata	CNRAIGA 1900060A	hybrid	34	D.rotundata	CNRAIGR 1500026	hybrid
35	D.alata	CNRAIGA 1900087	hybrid	35	D.rotundata	CNRAIGR 1500042	hybrid
36	D.alata	CNRAIGA 1900096	hybrid	36	D.rotundata	CNRAIGR 1600008	hybrid
37	D.alata	CNRAIGA 1900107	hybrid	37	D.rotundata	CNRAIGR 1600023	hybrid
38	D.alata	CNRAIGA 1900121	hybrid	38	D.rotundata	CNRAIGR 1600030	hybrid
39	D.alata	CNRAIGA 1900135	hybrid	39	D.rotundata	CNRAIGR 1600038	hybrid
40	D.alata	CNRAIGA 1900141	hybrid	40	D.rotundata	CNRAIGR 1600068	hybrid
41	D.alata	CNRAIGA 1900179	hybrid	41	D.rotundata	CNRAIGR 1700089	hybrid
42	D.alata	CNRAIGA 1900247A	hybrid	42	D.rotundata	CNRAIGR 1700112	hybrid
43	D.alata	CNRAIGA 1900306	hybrid	43	D.rotundata	CNRAIGR 1700183	hybrid
44	D.alata	CNRAIGA 1900344	hybrid	44	D.rotundata	CNRAIGR 1700445	hybrid
45	D.alata	CNRAIGA 19001417	hybrid	45	D.rotundata	CNRAIGR 1700614	hybrid
46	D.alata	CRNAIGA 1500020	hybrid	46	D.rotundata	CNRAIGR 1700635	hybrid
47	D.alata	CRNAIGA 1900120	hybrid	47	D.rotundata	CNRAIGR 1700695	hybrid
48	D.alata	CNRAIGA 1900139	hybrid	48	D.rotundata	CNRAIGR 1700786	hybrid

49	D.alata	INCONNU	hybrid	49	D.rotundata	CNRAIGR 1700938	hybrid
50	D.alata	N°088 AZAGUIE	traditional	50	D.rotundata	CNRAIGR 1700965	hybrid
51	D.alata	N°03 GBAGARA	traditional	51	D.rotundata	CNRAIGR 1701150	hybrid
52	D.alata	N°04 CAMEROUN	traditional	52	D.rotundata	CNRAIGR 1701157	hybrid
53	D.alata	N°07 BETE BETE	traditional	53	D.rotundata	TDr1000459	hybrid
54	D.alata	N°21 BETE BETE	traditional	54	D.rotundata	KPONAN VIOLET	traditional
55	D.alata	N°36 NZA BETE	traditional	55	D.rotundata	KRENGLE	traditional
56	D.alata	N°42 GHANA NZIAWA	traditional	56	D.rotundata	N°09 YAM 6	traditional
57	D.alata	N°50 AKASSA	traditional	57	D.rotundata	N°5 DAHOMEY MULT	traditional
58	D.alata	N°60 N'ZAKPITCHIKPOKPO	traditional	58	D.rotundata	N°21 PAHINTE	traditional
59	D.alata	N°74 N'ZA VIOLET	traditional	59	D.rotundata	N°25 KAWALE GNAN	traditional
60	D.alata	SOGLAN	traditional	60	D.rotundata	N°31 SAMMAN BOMA MUT	traditional
61	D.alata	SOPIE GNAMI	traditional	61	D.rotundata	N°42 GHANA NZIAWA	traditional
62	D.alata	TABA	hybrid	62	D.rotundata	N°42 ZREZROU	traditional
63	D.alata	TDa0100018	hybrid	63	D.rotundata	N°76 KRIKRIGNAN	traditional
64	D.alata	TDa0100090	hybrid	64	D.rotundata	PILIPIMKOU	traditional
65	D.alata	TDa1510080	hybrid	65	D.rotundata	TDr0100406	hybrid
66	D.alata	TDa1515032	hybrid	66	D.rotundata	TDr1000006	hybrid
67	D.alata	TDa1100432	hybrid	67	D.rotundata	TDr1000061 MULT	hybrid
				68	D.rotundata	TDr 1000360	hybrid
				69	D.rotundata	TDr7000061 MULT	hybrid
				70	D.rotundata	TDr9518544	hybrid
				71	D.rotundata	ZIEZOU 266	traditional

2.2 Methodology

The instrumental measurement of extensibility (which is supposed to represent sensory stretchability), may be considered as an important procedure for measuring quality parameter in selecting yam genotypes for pounded yam. 138 genotypes of yams from CNRA collection were collected in 2025 to observe textural characteristics of the yams regarding their pounded yam extensibility. The SOP used for this analysis is published https://doi.org/10.18167/agritrop/00787. Two replications consisting of 3 to 7 measurements per replicate were considered.

2.3 Statistical analysis

Results were analyzed using JMP PRO17. One-factor ANOVA tests and principal component analysis were performed. Hierarchical clustering was used for classification of the genotypes into clusters based on the extensibility texture of pounded yam.

3 RESULTS

3.1 Evolution of KDGE Extensibility parameters according species yam

The table below (Table 2) shows the effect of the two yam species on each extensibility textural parameter. There is a significant effect of the yam species on the extensogram peak force (hardness), extensibility (elongation) and extension area (energy or work done to extend). For the species (i.e. *alata* and *rotundata*), the most discriminant textural parameter is the extensibility ($P = 1.51e^{-69}$, F ratio 380.5). The yam species of *Dioscorea rotundata* had higher extensogram peak force, extensibility and extension area than the species of *Dioscorea alata* origins.

Table 2: Oneway Anova of Extensogram peak force (N), extensibility (mm) and extension area (N.mm) by Specie

	Extensogram peak force (N)					**Extensibility (mm)**					**Extension area (N.mm)**				
Source	DF	SSq	MSq	F ratio	*P value*	DF	SSq	MSq	F ratio	*P value*	DF	SSq	MSq	F ratio	*P value*
Specie	1	0.167	0.166	142.96	**6.27e-49**	1	697.78	697.78	380.48	**1.51e-69**	1	8.93	8.93	249.71	**6.27e-49**
	Mean + Std Dev			**Ranking**		**Mean + Std Dev**			**Ranking**		**Mean + Std Dev**			**Ranking**	
D. rotundata	0.113 ± 0.041			A		3.526 ± 1.817			A		0.341 ± 0.262			A	
D. alata	0.086 ± 0.026			B		1.653 ± 0.667			B		0.126 ± 0.070			B	

Levels not connected by same letter are significantly different.

3.2 Instrumental KDGE extensibility parameters of yam genotypes

The table 3 below shows the effect of yam genotypes on each texture parameters. There is a significant effect of genotype on extensogram peak force, extensibility and extension area. The genotypes are significantly different in KDGE parameters depending on the genotype and specie. For the genotypes, the most discriminant textural parameter is the extension area ($P = 6.3e^{-301}$, F ratio 65.6), i.e. the work done or energy expended to stretch or extend the pounded yam samples.

Table 3 Oneway Anova of Extensogram peak force (N), extensibility (mm) and extension area (N.mm) by genotype

Source	**DF**	**Sum of Squares**	**Mean Square**	**F** ratio	**Prob <F**
Extensogram peak force					
Genotype	137	1.0598784	0.007736	37.5957	**6.6e-264**
Extensibility (mm)					
Genotype	137	1955.7121	14.2753	47.0262	**1.9e-266**
Extension area (N.mm)					
Genotype	137	34.056692	0.248589	65.6481	**6.3e-301**

3.3 Correlation between KDGE extensibility parameters of pounded yam

The table below shows the correlations between the different variables and the *p*-value. All variables are strongly and positively correlated with each other. Thus, a variety with high extensibility requires a high extension force and likely to have high extensogram peak force.

Table 4: Correlation betwen KDGE extensibility parameters

	Extensogram peak force (N)	Extensibility (mm)	Extension area (N.mm)
		coefficient	
Extensogram peak force (N)	1		
Extensibility (mm)	0.7045	1	
Extension area (N.mm)	0.8218	0.9565	1
		***P* value**	
Extensogram peak force (N)	1		
Extensibility (mm)	<.0001	1	1
Extension area (N.mm)	<.0001	<.0001	<.0001

Pearson's corrélation ; P values < 0.05 are significant

3.4 Screening of KDGE extensibility of pounded yam

3.4.1 Discriminant analyses of KDGE extensibility of pounded yam from 138 genotypes

The first two components of the PCA explains 99.2% of the variation in the textural parameters of pounded yams. The genotypes such as **KPONAN VIOLET, N°09 YAM 6, CIVCDR 150, CIVCDR 423, CIVCDR 451, CNRAIGR 1600068, ZIEZOU 266, CIVCDR 074, CIVCDR 082,** and **CNRAIGR 1700695** are situated on the upper right positive section of the PCA and are the most associated with extensibility. The genotypes such as **PILIPIMKOS, SOPIE GNAMI, CIVCDR 452, N°76 KRIKRIGNAN IGR1700938, CNRAIGR 1701157, N°31 SAMMAN BOMA MUT, CNRAIGA 1900087, CRNAIGA 1900120, CNRAIGR 1700938, ALLUSHI** and **TABA** are situated in the positive and negative sections of component 1 and positive sections of component 2, and are also associated to extensibility but to a lower extent. The remaining genotypes which are overwhelmingly *alata* genotypes are situated in the component opposite to the sector of extensibility in the negative sectors of components 1 and 2.

The PCA also showed that the vast majority of *alata* genotypes are in the lower left sector and separate from the majority of *rotundata* in the upper right sector. There are some *rotundata* genotypes that have poor extensibility properties such as **CIVCDR 060, CIVCDR 458, CNRAIGR 1500042, CNRAIGR 1700445**, etc, as well as some *alata* genotypes with fairly good extensibility such as **IGA 1900139, TABA, N° 31 SAMMAN BOMA MUT, CNRAIGA 1900120.**

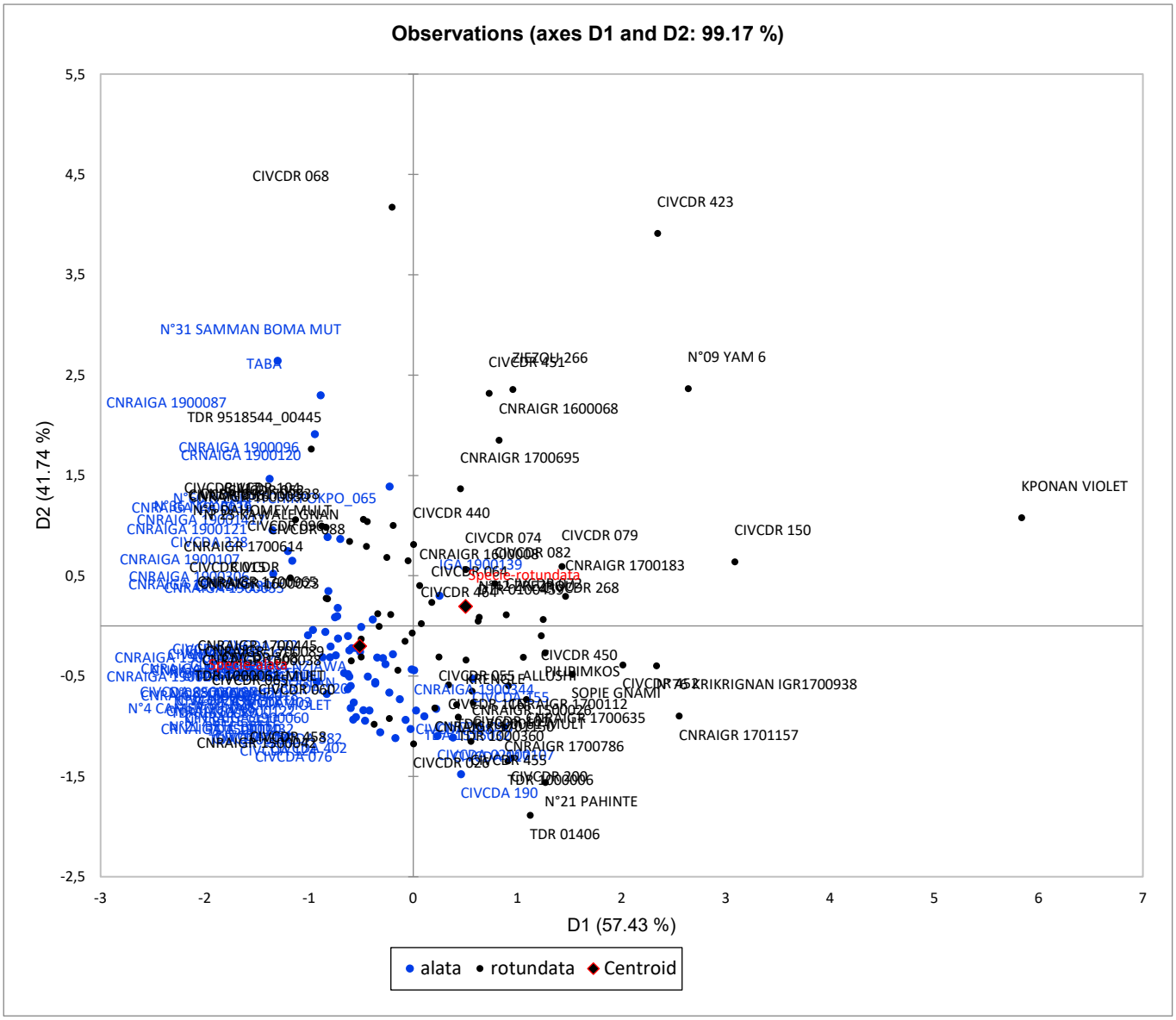

Figure 1 : Projection of the 138 genotypes in the factorial plane (D1 X D2)

3.4.2 Discriminant analysis

The discriminant analysis reveals good discrimination among the genotypes, particularly for the genotypes **KPONAN VIOLET, N°09 YAM 6, CIVCDR 150, CIVCDR 423** which have high extensibility.

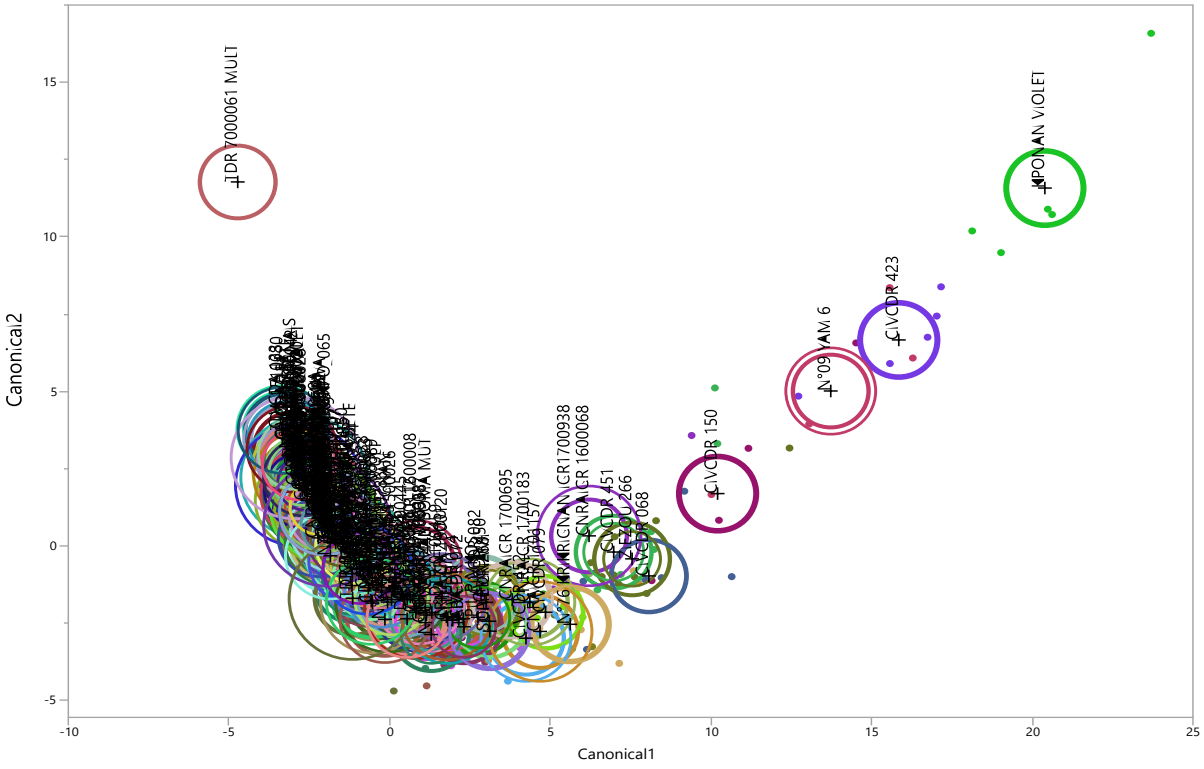

Figure 2: Discriminant analysis of pounded yam from 138 yam genotypes

3.4.3 Hierarchical classification of yam genotypes based of KDGE extensibility

The class-cluster hierarchy reveal the genotypes with high extensibility peak force and work done for extensibility, making them possibly more suitable for pounded yam, such as **KPONAN VIOLET, N°09 YAM 6, CIVCDR 150, CIVCDR 423, CIVCDR 451, CNRAIGR 1600068, ZIEZOU 266, CIVCDR 074, CIVCDR 082,** and **CNRAIGR 1700695** and should be considered for selection of yam for improved breeds. Conversely, varieties such as **PILIPIMKOS, SOPIE GNAMI, CIVCDR 452, N°76 KRIKRIGNAN IGR1700938, CNRAIGR 1701157, N°31 SAMMAN BOMA MUT, CNRAIGA 1900087, CRNAIGA 1900120, CNRAIGR 1700938, ALLUSHI** and **TABA** may be considered to have intermediate extensibility and may also be considered for selection. The third cluster consist of largely *alata* genotypes with poor extensibility (Figure 3 & Table 5).

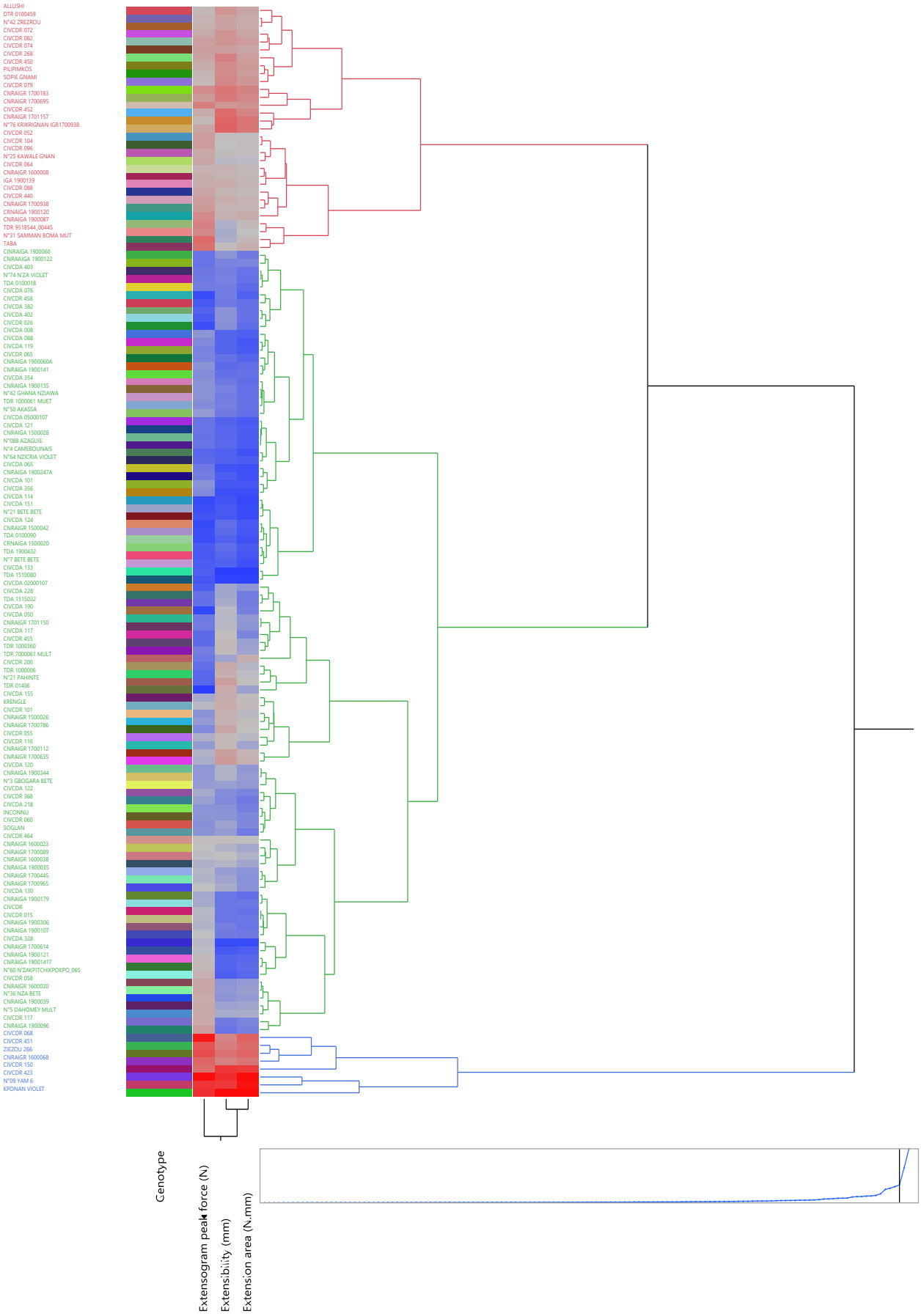

Figure 3: Three-class hierarchical clustering of 138 yam genotypes base on pounded yam extensibility

Table 5: Classification of 138 genotypes and their quality traits of pounded yam

Cluster	Varieties	Number	Pounded yam quality
1	Kponan violet, N°09 YAM 6, CIVCDR 150, CIVCDR 423, CIVCDR 451, CNRAIGR 1600068, ZIEZOU 266, CIVCDR 074, CIVCDR 082, and CNRAIGR 1700695	10	high extensibility peak force and work done for extensibility, making them possibly more suitable for pounded yam
2	Pilipimkou, Sopie gnami, CIVCDR 452, N°76 Krikrignan, CNRAIGR 1701157, N°31 Samman boma, CNRAIGA 1900087, CNRAIGA 1900120, CNRAIGR 1700938, Allushi and **TABA** CIVCDR 052, CIVCDR 064, CIVCDR 072, CIVCDR 079, CIVCDR 096, CIVCDR 104, CIVCDR 268, CIVCDR 450, CNRAIGR 1600008, CNRAIGR 1700183,	21	Intermediate extensibility with medium quality pounded yam
3	CNRAIGA 1900060, CIVCDA 008, CIVCDA 02000107, CIVCDA 050 CIVCDA 05000107, CIVCDA 065, CIVCDA 076, CIVCDA 088, CIVCDA 101, CIVCDA 114 CIVCDA 117, CIVCDA 119, CIVCDA 120, CIVCDA 121, CIVCDA 122, CIVCDA 124, CIVCDA 130, CIVCDA 133, CIVCDA 151, CIVCDA 155, CIVCDA 190, CIVCDA 218, CIVCDA 228, CIVCDA 328, CIVCDA 354, CIVCDA 356, CIVCDA 382, CIVCDA 402, CIVCDA 403, CNRAIGA 1900122, CNRAIGA 1500028, CNRAIGA 1900035, CNRAIGA 1900039, CNRAIGA 1900060A, CNRAIGA 1900096, CNRAIGA 1900107, CNRAIGA 1900247A, CNRAIGA 1900121, CNRAIGA 1900135, CNRAIGA 1900141, CNRAIGA 1900179, CNRAIGA 1900306, CNRAIGA 1900344, CNRAIGA 19001417, CNRAIGA 1500020, CNRAIGA 1900139, INCONNU, N°088 Azaguie, N°03 Gbagara, N°04 Cameroun, N°07 Bete bete, N°21 Bete bete, N°36 Nza bete N°42 Ghana nziawa, N°50 Akassa, N°60 N'zakpitchikpokpo, N°74 N'za violet, Soglan,TDa0100018, TDa0100090, TDa1510080, TDa1515032, TDa1100432, CIVCDR, CIVCDR 015, CIVCDR 026, , CIVCDR 055, CIVCDR 058, CIVCDR 060, CIVCDR 065, CIVCDR 068, CIVCDR 088, CIVCDR 101, CIVCDR 116, CIVCDR 117, CIVCDR 200, CIVCDR 368 CIVCDR 440, CIVCDR 455, CIVCDR 458, CIVCDR 464, CNRAIGR 1500026, CNRAIGR 1500042, CNRAIGR 1600023, CNRAIGR 1600030, CNRAIGR 1600038, CNRAIGR 1700089, CNRAIGR 1700112, CNRAIGR 1700445, CNRAIGR 1700614, CNRAIGR 1700635, CNRAIGR 1700786, CNRAIGR 1700965, CNRAIGR 1701150, TDr1000459, KRENGLE, N°09 YAM 6, N°5 DAHOMEY , N°21 PAHINTE, N°25 Kawale gnan, N°42 GHANA NZIAWA, N°42 Zrezrou, TDr0100406, TDr1000006, TDr100006 TDr1000360, TDr7000061, TDr9518544	107	poor extensibility with a less appreciated non-extensible pounded yam.