

NIRS Measurements of Fresh Yam and Fresh Cassava

Ibadan, Nigeria, July 2019

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<u>Ethics</u>: The activities, which led to the production of this manual, 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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NIRS measurements of fresh yam and fresh cassava

Karima MEGHAR, CIRAD

RTBfoods NIRS training, 1st July 2019, Ibadan, Nigeria



- I. NIRS measurement protocol to study the longitudinal and radial heterogeneity of DM in fresh yam of 4 varieties from Benin
- II. NIRS measurement protocol to study the longitudinal distribution of DM and texture in fresh cassava of 17 varieties from CIAT(Colombia)

1 NIRS Measurement Protocol to Study the Longitudinal and Radial Heterogeneity of DM in Fresh Yam of 4 Varieties from Benin





NIRS measurement protocol to study the longitudinal and radial heterogeneity of DM in fresh yam of 4 varieties from Benin

Fresh yam samples used

Number of varieties

4 varieties Ala, Deba, Kpaigninan and Kpété from Benin were used in this study.

Period of harvest

Those varieties were harvested in December 2018 and then were stored in cooled room (14°C) to May 2019.

Size of tuber

The tubers

should have a

representative

size, at least 20

cm of length and

5 cm of diameter

Before cutting

The tubers were peeled, washed and wiped with a paper towels.

Sample preparation of fresh yam tuber



NIR spectra measurements

- NIR spectra were collected using a monochromator ASD Labspec.
- 3 spectra (S2 in the center and S1, S3 in the edges) were acquired for each slice of each cube in Reflectance mode (350-2500 nm).
- The order of measurements was from C1 to C5 and for each cube from H1 to HI.





Numb	Number of spectra acquired					
Genotype	No tuber	No Cube	No of slices	No of spectra		
Ala	T1	5	40	120		
	T2	5	40	120		
Deba	T1	5	38	114		
	Т2	5	32	96		
Kapigninan	T1	5	33	99		
	Т2	5	34	102		
Kpété	T1	5	37	111		

Samples codification

ABCTnCmHlSk

n : number tubers from 1 to 2 m : number of cubes from 1 to 5 I : number of slices from 1 to 1 k : number of replicates from 1 to 3

Data processing : PCA on all resulting NIR spectra

Classification by genotype : PCA on SG (1,5,5,1)+SNV (1000-2330 nm) spectra



- > Along PC4 (3%) axis, we see a clear classification between varieties.
- Along PC4 axis, we see also an important diffrence between tuber T1 and tuber T2 of Kapignan variety. it is probably due to oxidation of one of tuber during spectra acquisition.
- ➢ No discrimination along PC1 (68%), PC2(19%), PC3(7%) and PC5(1%).

Data processing : PCA on resulting NIR spectra classification by cube : PCA on SG (1,5,5,1)+SNV (1000-2330 nm) spectra



- > No descrimination along all axis.
- > Because, the variability between varieties is higher than those between cubes.

C5

Data processing : PCA on resulting NIR spectra PCA on SG (1,5,5,1)+SNV (1000-2330 nm) spectra : ANOVA analysis on scores value of PC4

We use ANOVA to demonstrate if vartiability between varieties, cubes, slices (Hauteur) and repetition are significantly different .

Analyse Type I Sum of Squares (PC-4) :

		Somme des	Moyenne des		
Source	DDL	carrés	carrés	F	Pr > F
Variété	3	84,219	28,073	176,624	< 0,0001 🦷
Cube	5	2,784	0,557	3,504	0,004
Hauteur	7	1,316	0,188	1,183	0,310
repetition	2	0,072	0,036	0,226	0,798
Variété*Cube	12	9,829	0,819	5,153	< 0,0001
Variété*Haute					
ur	21	1,057	0,050	0,317	0,999
Variété*repeti					·
tion	6	0,138	0,023	0,145	0,990
Cube*Hauteur	28	1,868	0,067	0,420	0,997
Cube*repetitio					
n	8	0,236	0,029	0,185	0,993 🖵
Hauteur*repet					
ition	14	0,256	0,018	0,115	1,000

The results of Fisher test with a materiality threshold of 5 % shows that the difference is significant between varieties and between cubes, but no significant between slices and between repetition.

The difference between varieties is > 40 times higher than those between cubes.

Data processing : PCA on Deba variety NIR spectra PCA on SG (1,5,5,1)+SNV (1000-2330 nm) spectra

The purpose of this work is to study the variability whithin genotype (Deba)



Along PC5 axis, we see a clear classification according to the location proximal (C1,C2) in the positive part of this axis, distal (C4,C5) in negative part and central (C3) is allocated between them.

Data processing : PCA on Deba genotype NIR spectra

PCA on SG (1,5,5,1)+SNV (1000-2330 nm) spectra

ANOVA on score values of PC5

Somme des Moyenne					
Source	DDL	carrés	des carrés	F	Pr > F
Tuber	1	0,091	0,091	7,411	0,008
Cube	4	3,109	0,777	63,255	< 0,0001
Slice	4	0,038	0,010	0,775	0,544
Tuber*Cube	4	0,322	0,081	6,560	0,000
Tuber*Slice	4	0,064	0,016	1,300	0,276
Cube*Slice	16	0,212	0,013	1,080	0,384

Difference between cubes

Cube / Fisher (LSD) / Analyse des différences avec un intervalle de confiance à 95% (PC-5) :

Différenc

		- C			
	Différenc st	andardi	Valeur		Significati
Contraste	е	sée	critique	Pr > Diff	f
C1 vs C5	0,370	12,919	1,985	< 0,0001	. yes
C1 vs C4	0,267	9,211	1,985	< 0,0001	. yes
C1 vs C3	0,133	4,660	1,985	< 0,0001	
C1 vs C2	0,013	0 <i>,</i> 459	1,985	0,647	No
C2 vs C5	0,357	12,459	1,985	< 0,0001	yes
C2 vs C4	0,254	8,758	1,985	< 0,0001	. yes
C2 vs C3	0,120	4,200	1,985	< 0,0001	. yes
C3 vs C5	0,236	8,259	1,985	< 0,0001	. yes
C3 vs C4	0,134	4,611	1,985	< 0,0001	. yes
C4 vs C5	0,103	3,542	1,985	0,001	. yes
LSD-value					
:			0,057		

Difference between slices

Slice / Fisher (LSD) / Analyse des différences entre les modalités avec un intervalle de confiance à 95% (PC-5) :

Différen							
ce							
Contrast	Différen s	tandard	Valeur		Significat		
e	ce	isée	critique	Pr > Diff	if		
H1 vs H3	0,043	1,514	1,985	0,133	No		
H1 vs H5	0,040	1,370	1,985	0,174	No		
H1 vs H2	0,033	1,155	1,985	0,251	No		
H1 vs H4	0,029	1,013	1,985	0,314	No		
H4 vs H3	0,014	0,501	1,985	0,618	No		
H4 vs H5	0,011	0,370	1,985	0,713	No		
H4 vs H2	0,004	0,142	1,985	0,888	No		
H2 vs H3	0,010	0,359	1,985	0,720	No		
H2 vs H5	0,007	0,230	1,985	0,819	No		
H5 vs H3	0,004	0,125	1,985	0,901	No		
LSD-							
value :			0,057				

Significant spectral difference between tuber of the same genotype and between the cube of the same tuber

No significant difference between slices

Data processing : Prediction of dry matter in fresh yam

Wet chemistry : Reference values of dry matter

DM in fresh yam was analyzed by freeze dried during 72h



ANOVA on DM values

Source	DDL	Somme des carrés	Moyenne des carrés	F	Pr > F
Variety	2	321,336	160,668	42,727	< 0,0001
Tuber	1	688,241	688,241	183,026	< 0,0001
Cube	4	302,937	75,734	20,140	< 0,0001
Slice	4	5,988	1,497	0,398	0,810
Varieté*Tubercule	2	1157,056	578,528	153,849	< 0,0001
Varieté*Cube	8	293,089	36,636	9,743	< 0,0001
Varieté*Hauteur	8	44,198	5,525	1,469	0,179
Tubercule*Cube	4	207,018	51,754	13,763	< 0,0001
Tubercule*Hauteur	4	4,078	1,019	0,271	0,896
Cube*Hauteur	16	44,199	2,762	0,735	0,752

> This is in line with previous results of ANOVA applied to spectral data

Data processing : prediction of dry matter in fresh yam PLS model for dry matter : Mean spectra by replicat SG (1,5,5)+SNV (1000-2330 nm) without DEBT1C2H6



Data processing : prediction of dry matter in fresh yam PLS model for prediction of dry matter : Mean spectra by slices (1000-2330 nm) + SG (2,10,10)+SNV



Conclusions and perspectives NIRS and Wet chemistry Conclusions

- Significant difference between varieties and tubers with a materiality threshold of 5 %.
- Significant difference between the proximal, central and distal cubes with a materiality threshold of 5 %.
- No significant difference between slices of the same cube and between repetition of the same slice.
- Significant longitudinal difference and No significant radial difference in the yam tuber.
- The performances of calibration developed with spectra meaning by slices (R²=0.96, RMSECV=1.26 %) are better than those developed with the spectra meaning by repetition (R²=0.94, RMSECV=1.60 %).

Perspectives

- For furthers analyses we will keep 5 cubes, 3 slices and no repetition.
- The mean spectra of each cube will be taked.
- DM calibration could be improved by adding a new samples in data base.

2 NIRS Measurement Protocol to Study the Longitudinal Distribution of DM and Texture in Fresh Cassava of 17 Varieties from CIAT (Colombia)





NIRS measurement protocol to study the I distribution of DM and texture in fresh cassava of 17 varieties from CIAT(Colombia)

Sample preparation



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NIRS measurements

One spectra was acquired for each sample, with the order E1 to E8

- Number of genotypes : 17
- Total number of samples : 188
- Spectral range and acquisition mode : Absorbance (400-2500 nm)
- Spectrometer : DS2500 (FOSS)
- Acquisition Software : ISIscan (FOSS)
- Data Traitement software : Unscrambler
- Codification of samples :

Exemple : COL1222 Pn Rm El

Genotype name plant number root number sample number

Number of spectra

Genotype	Date of	No of plants	No of	No of samples	
	measurement		roots		
PAN39	05/03/2019	1	1	8	
VEN77	05/03/2019	1	1	8	
PER183	05/03/2019	1	1	8	
VEN208	05/03/2019	1	1	8	
BRA512	06/03/2019	1	1	8	
VEN25	06/03/2019	1	1	8	
COL722	06/03/2019	1	1	8	
CR37	07/03/2019	1	1	8	
ECU43	07/03/2019	1	2	16	
COL2387	11/03/2019	1	1	8	
COL2510	11/03/2019	1	1	8	
VEN210	11/03/2019	1	1	8	
BRA492	11/03/2019	1	2	14	
PAN139	11/03/2019	1	2	14	
COL1222	11/03/2019	1	1	8	
CM9460	13/03/2019	1	2	16	
SM1219	13/03/2019	2	4 (2 per plant)	32	

Data processing Difference between perpendicular and parallel spectra

188 raw spectra Chemometrics (PCA) Spectra processing 916-2200 nm (SNV+ detrend), Scores plot PC1-PC2 ANOVA on PC1 values Scores 0,4 Paran 0,3 Somme des Moyenne des 0,2 carrés Source DDL carrés Pr > F 0,1 Modèle 1 3,375 3,375 2,207 0,139 (2%) က် ပြ -0,1 282,887 1,529 Erreur 185 -0,2 Total corrigé 186 286,262 Para -0,3 -0,4 -0,5

-0,6

-3

PC-1 (88%)

Data processing

Difference between varieties

183 raw spectra Chemometrics (PCA) Spectra processing 916-2200 nm (SNV+ detrend) Scores plot PC1-PC2 Scores plot PC1-PC2 without PAN139 Scores Scores 0 П 0.1 * 🗆 00 **A**. PC-3 (1%) PC-2 (8%) -0,1 -0,2 -2 0 -0,3 -3 -2 -1,9 -1,8 -1,7 -1,6 -1,5 -1,4 -1,3 -1,2 -1,1 -1 -0,9 -0,8 -0,7 -0,6 -0,5 -0,4 -0,3 -0,2 -0,1 0 0,1 0,2 0,3 0,4 0,5 0,6 0,7 0,8 0,9 --7 -3 -2 -1 PC-1 (91%) PC-1 (72%) COL2510 VEN210 COL1222 VEN77 COL2387 PAN39 COL2387 COL2510 VEN210 COL1222 PAN39 VEN77 • ▲ ٠ • PER183 BRA512 CR37 **VEN208** × VEN025 COL1722 PER183 0 **VEN208** +BRA512 × VEN025 0 COL1722 CR37 BRA492 CM9460 SM1219 ECU43R2 \diamond ∇ Ungrouped ECU43R2 \diamond PAN139 ∇ BRA492 CM9460 SM1219 Ungrouped

Prediction of DM in fresh cassava PLS for prediction DM and Texture

DM was measured by drying on oven at 48 °C during 48 h

Raw spectra



Spectra processing 916-2200 nm (SNV+ detrend)

Correlation between wet chemistry values and NIRS predicting value for DM



Correlation between wet chemistry values and NIRS predicting value for texture



Conclusions

- No significant difference between parallel and perpendicular spectra.
- No longitudinal difference in fresh cassava root.
- The DM and texture calibrations doesn't work.
- We will continue investigations in September with the huge data base coming from CIAT (Colombia).



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