Calibration Report

NIRS Analyses of Sensory & Textural Traits in Sweetpotato based on Spectra Collected on Raw-intact Roots

High-Throughput Phenotyping Protocols (HTPP), WP3

Kampala, Uganda, 29/11/2022

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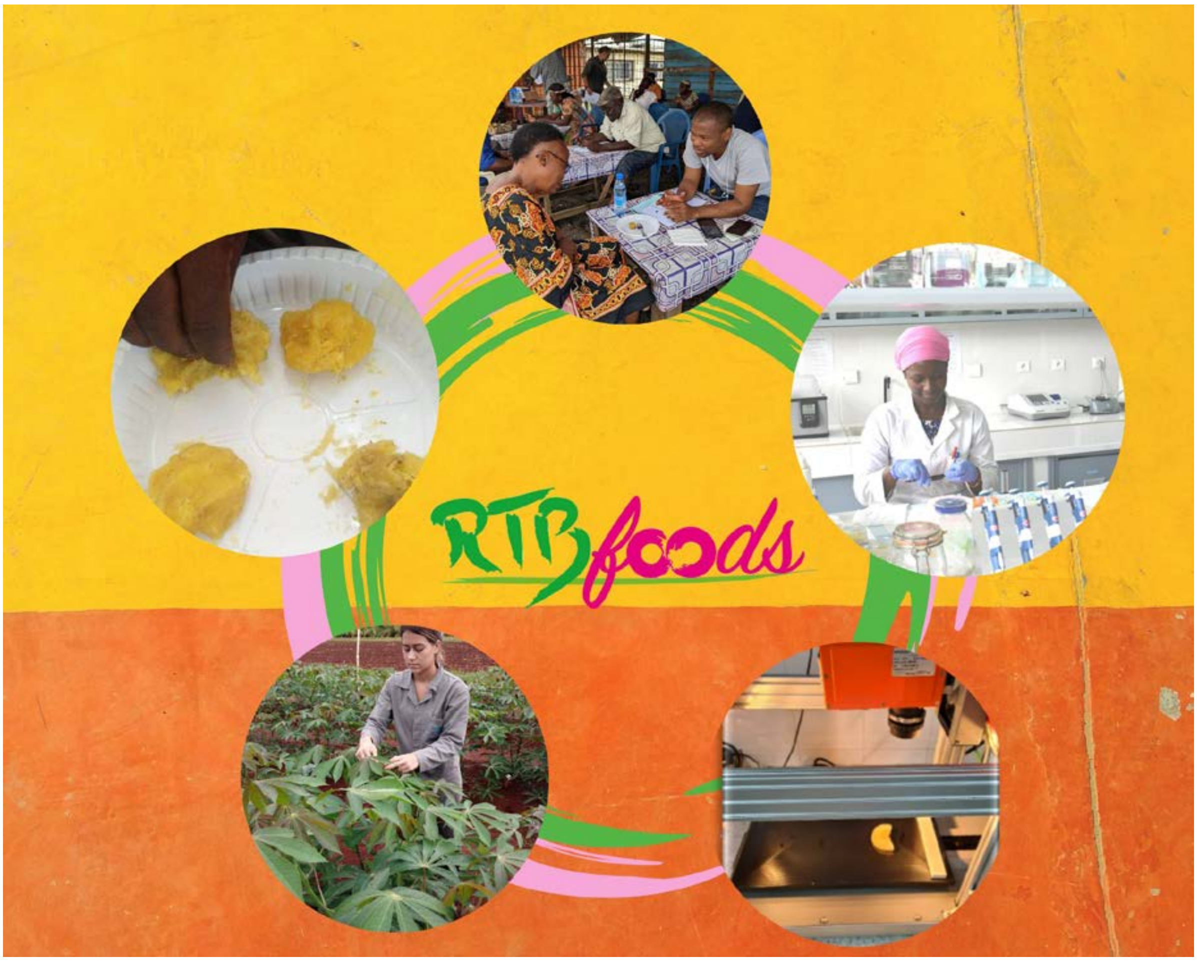

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Ethics: The activities, which led to the production of this manual, were assessed and approved by the CIRAD Ethics Committee (H2020 ethics self-assessment procedure). When relevant, samples were prepared according to good hygiene and manufacturing 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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ABSTRACT

Context: This scientific report concerns NIRS calibrations of sweetpotato sensory traits. The spectral data were collected from raw-intact roots, while sensory data was collected from cooked roots.

Place: Uganda

Date: 29/11/2022

Authors: Judith S NANTONGO, Edwin SERUNKUMA, Gabriela BURGOS, Fabrice DAVRIEUX, Karima MEGHAR, Reuben SSALI (2022)

Content:

A spectral analysis of 217 sweetpotato genotypes was undertaken. These were collected from different CIP sweet potatoe genetic trials (GT) located in different agroecological zones (AEZ); West nile AEZ (Abii GT; L. Albert AEZ (Hoima and Buling GTs); Southern highlands (Kabale GT); Lake Victoria Crescent (Namulonge MDP); Western highlands (Rwebitaba MDP); and L.Kyoga basin (Serere GT). The samples were collected in two different seasons of 2021 and 2022. Harvests took place in the second season of 2021 (94 genotypes) (and the first season of 2022 (123 genotypes). Calibrations were done using reference data collected by a sensory panel as well as texture parameters assessed using a texture analyser. Up to twelve cooked roots per genotype were used for sensory evaluation of traits per session.

High performances were observed of the calibration for orange color intensity, suggesting that the model is sufficient for field application. The moderate performances aroma, flavor and mealiness could be used for initial screening purposes. Most of the calibrations still need improvement.

Key Words: Sweet Potato, NIRS, sensorial profiles, calibrations, chemometrics

1 DATA

1.1 Material

A total of 217 genotypes were collected from different CIP sweet potatoe genetic trials (GT) located in different agroecological zones (AEZ); West nile AEZ (Abii GT; L. Albert AEZ (Hoima and Buling GTs); Southern highlands (Kabale GT); Lake Victoria Crescent (Namulonge MDP); Western highlands (Rwebitaba MDP); and L.Kyoga basin (Serere GT). The samples were collected in two different seasons of 2021 and 2022. Harvests took place in the second season of 2021 94 genotypes) (and the first season of 2022 (123 genotypes). The preparation of the raw-intact roots for spectral analysis is detailed in the standard operating procedure on NIR spectra collection (Nantongo 2022) .

1.2 Sensory and texture parameters

Sensory parameters were assessed by the sensory panel while texture parameters were assessed using a texture analyser (Table 1). Up to twelve cooked roots per genotype were used for sensory evaluation of traits. The protocol for descriptive sensory analysis established for sweetpotato that was used has been previously described (Nakitto 2020; Nakitto *et al.* 2022), where, up to 12 trained panellists consumed small cubes of each cooked sweetpotato genotype and rated the overall liking, color and aroma liking of the samples on a 10-point hedonic scale ranging from 1 (dislike extremely) to 10 (like extremely), for each sensory trait per genotypes. They also rated sweetness, mealiness and firmness on just-about-right scales ranging from 1 to 10. The samples assessed per session were equivalent to the number of panel members. In addition, the average peak positive force for the first and second compressions texture of each piece were analysed using a TA-XT texture analyzer (Stable Macro Systems, Godalming, UK) with 10 kg load cell, following a texture profile analysis (TPA) procedure.

Table 1: Descriptive statistics of the sensory parameters assessed in raw-intact sweetpotato roots

#	Parameter	N	Mean	SD	Min	Max
1	Sweetpotato aroma	651	5.76	1.31	1	8.1
2	Caramel aroma	651	0.56	1.13	0	6.92
3	Pumpkin aroma	651	0.37	0.61	0	3.96
4	Off odour	651	0.17	0.29	0	1.86
5	Orange color intensity	651	3.7	2.99	0	9.18
6	Uniformity of color	651	7.12	1.11	1.75	9.64
7	Degree of transluscency	651	1.25	1.24	0	8.33
8	Fibrous appearance	651	0.9	0.6	0	4.51
9	Sweetpotato flavor	651	5.82	1.45	0.67	8.3
10	Pumpkin flavor	651	0.67	1.27	0	6.83
11	Cooked carrot flavor	651	0.12	0.25	0	1.67
12	Floral flavor	651	0.11	0.17	0	1
13	Sweet taste	651	5.25	1.55	0	7.7
14	Bitter taste	651	0.25	1.05	0	6.42
15	Hardness by hand	651	4.32	1.73	0	8.78
16	Moisture release	651	0.84	1.31	0	7.25
17	Cohesiveness	651	5.75	2.5	0.17	9.31
18	Crumbliness/Mealiness by hand	651	4.92	2.33	0.33	9.25
19	Fracturability	651	3.81	2.06	0.27	8.25

#	Parameter	N	Mean	SD	Min	Max
20	Firmness/ Hardness	651	3.86	1.29	0.73	7.78
21	Crunchiness	651	0.6	0.83	0	5.83
22	Moisture in mass	651	4.25	2.2	0	8.9
23	Crumbliness	651	4.67	2.25	0.2	8.67
24	Adhessiveness (Stickiness)	651	1.53	0.83	0.11	6.58
25	Fibrousness	651	0.72	0.72	0	4.67
26	Smoothness	651	6.45	1.79	0.58	9.45
27	Rate of breakdown	651	6.13	1.28	2.13	8.88
28	Dry matter	651	34.96	7.73	4.5	46.62
29	Peak positive force 1	588	4783	2207	1473	12709
30	Peak positive force 2	588	3432	1524	1097	9780
31	Positive Area 1	588	8587	3688	2716	18384
32	Positive Area 2	585	3341	1665	1022	9599
33	Optimal cooking time	418	22.55	7.8	10	55
34	Water absorption1	522	1.42	2.18	-5.1	9.08
35	Water absorption2	107	2.26	2.49	-2.53	7.71

2 RESULTS

2.1 Near Infrared Spectroscopy

2.1.1 Exploration

The spectra patterns from the 5 sites are depicted in Figure 1. There are 5 peaks, typical of sweetpotato spectra. The shape of the spectra from the different genetic trials did not differ.

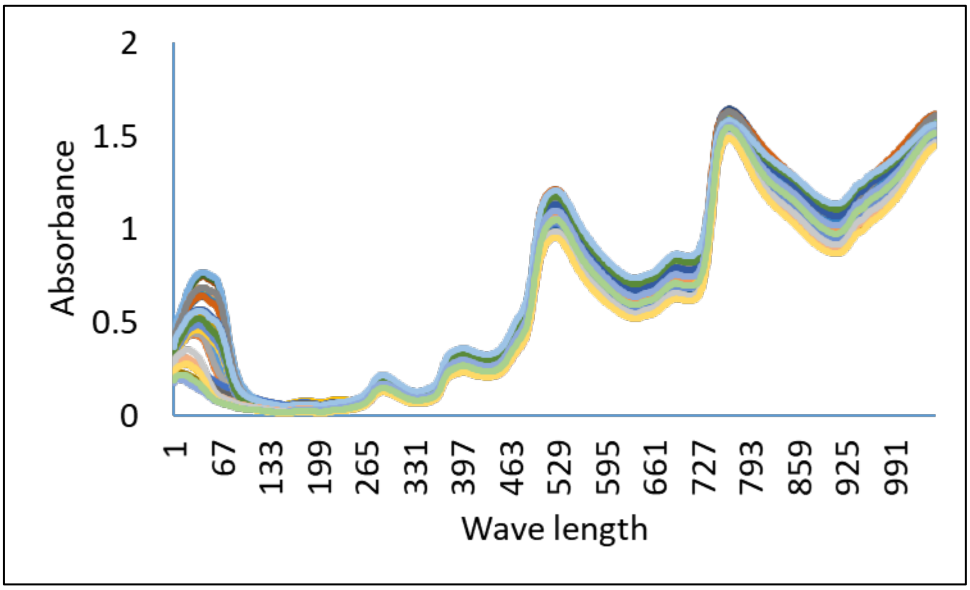

Figure 1 : NIRS spectra of raw intact sweetpotato

2.1.2 Spectra: Principal Components Analysis

A PCA calculated on the spectra (spectral range NIR) of the samples shows that 86 % of variance is explained by the 2 first PCs. Although the significance of the clustering among the different sites or years was not tested, some samples from particular sites such as Namulonge and Serere (Figure 2) appeared to be distant from the others. Similarly, some samples collected in 2021, seemed to be distant from the clusters (Figure 3).

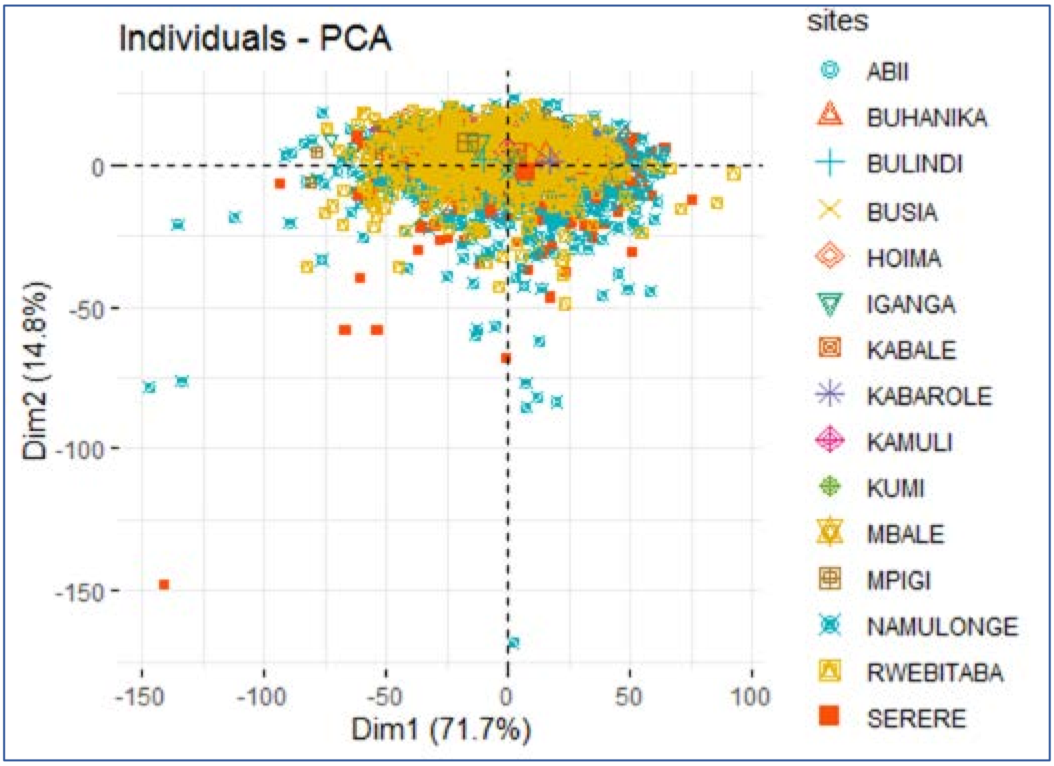

Figure 2 : PCA plot of the spectra collected from different sites

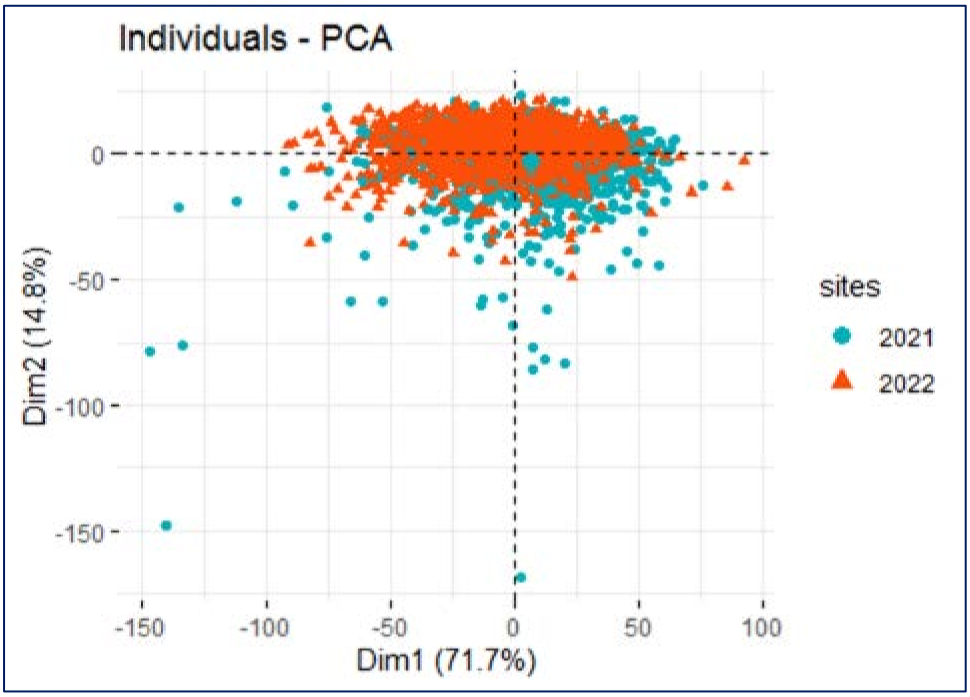

Figure 3 : PCA plot of the spectra collected from different seasons

2.1.3 Quantitative analysis

The different parameters were calibrated using classical linear regression such as PLS regression, based on the full spectral range with no pre-treatments (Table 2). The training population was 80% of the total sample size. The models were evaluated based on R^2.

Table 2: R^2, standard error of cross validation (SECV) and number of components of NIRS calibrations for the sensory parameters of sweetpotato roots based on full spectra collected from raw-intact roots

#	Parameter	R^2	SECV	# components
1	Sweetpotato aroma	0.51	0.72	6
2	Caramel aroma	0.19	0.29	7
3	Pumpkin aroma	0.50	0.45	6
4	Off odor	0.07	0.12	2
5	Orange color intensity	0.88	1.06	7
6	Uniformity of color	0.22	0.89	7
7	degree of translucency	0.16	0.55	7
8	Fibrous appearance	0.07	0.62	5
9	Sweetpotato flavor	0.25	1.14	5
10	Pumpkin flavor	0.58	0.42	7
11	Cooked carrot flavor	0.16	0.18	7
12	Floral flavor	0.11	0.16	6
13	Sweet taste	0.13	1.23	5
14	Bitter taste	0.02	0.08	1
15	Hardness by hand	0.44	1.33	6
16	Moisture release	0.34	1.03	6
17	Cohessiveness	0.40	2.08	6
18	Mealiness by hand	0.55	1.66	6
19	Fractrability	0.44	1.79	7
20	Firmness/Hardness	0.40	1.19	6
21	Crunchiness	0.16	0.40	5
22	Moisture in mass	0.58	1.51	7
23	Crumbliness	0.50	1.69	6
24	Adhessiveness	0.09	0.54	7
25	Fibrousness	0.05	0.73	2
26	Smoothness	0.36	1.39	6
27	Rate of breakdown	0.48	1.01	7
28	Dry matter	0.53	4.06	6
29	Peak positive force 1	0.38	1902.53	7
30	Peak positive force 2	0.39	1191.17	7
31	Positive Area 1	0.38	3050.17	6
32	Positive Area 2	0.31	1382.78	6
33	Optimal cooking time	0.30	6.73	6
34	Water absorption	0.13	2.01	3
35	Water absorption2	0.31	2.04	7

2.1.4 Statistics parameters for calibrations:

High performances were observed of the calibration for orange color intensity (R^2 =0.88), suggesting that the model is sufficient for field application. Moderate performances aroma, flavor and mealiness (R^2 ~ 0.50) were detected. Most of the calibrations still need improvement (R^2< 0.50). The external validation models for orange color intensity still performed well (R^2 =0.88), although performances of models for aroma, flavor and mealiness declined on external samples (Table 3).

Table 3: R^2 and standard error of prediction (SEP) of NIRS calibration for the sensory parameters of sweetpotato roots based on full spectra collected from raw-intact roots. 20% of the total number of samples were used for external validation.

#	Parameter	R^2	SEP
1	Sweetpotato aroma	0.36	0.74
2	Caramel aroma	0.25	0.27
3	Pumpkin aroma	0.67	0.33
4	Off odor	0.00	0.15
5	Orange color intensity	0.88	1.05
6	Uniformity of color	0.22	1.17
7	degree of translucency	0.10	0.50
8	Fibrous appearance	0.02	0.51
9	Sweetpotato flavor	0.35	0.97
10	Pumpkin flavor	0.43	0.52
11	Cooked carrot flavor	0.08	0.21
12	Floral flavor	0.04	0.16
13	Sweet taste	0.09	1.36
14	Bitter taste	0.00	0.07
15	Hardness by hand	0.29	1.45
16	Moisture release	0.34	1.09
17	Cohessiveness	0.29	2.25
18	Mealiness by hand	0.05	2.69
19	Fractrability	0.60	1.52
20	Firmness/Hardness	0.42	1.10
21	Crunchiness	0.34	0.33
22	Moisture in mass	0.50	1.52
23	Crumbliness	0.52	1.80
24	Adhessiveness	0.03	0.59
25	Fibrousness	0.16	0.46
26	Smoothness	0.07	1.43
27	Rate of breakdown	0.45	1.00
28	Dry matter	0.56	4.07
29	Peak positive force 1	0.34	1651.53
30	Peak positive force 2	0.22	1351.04
31	Positive Area 1	0.54	2773.61
32	Positive Area 2	0.29	1540.72
33	Optimal cooking time	0.16	8.93
34	Water absorption	0.11	2.35
35	Water absorption2	0.33	2.42

3 CONCLUSION

NIRS shows some potential to predict selected sensory parameters such as orange color. However, most of the calibrations are still poor and may be improved by adding additional samples, especially to minimise the seasonality effect. Collecting spectra from other sample types such as freeze-dried samples is encouraged.

A classification of sensory parameters based on spectral fingerprints should be tested. Indeed, by defining thresholds, or classes, by criterion, it will be interesting to investigate the possibility of classifying the genotypes in order to carry out a rapid selection. For this, methods such as PLSDA, SVM or SIMCA can be applied to spectral and sensory data sets.

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