Calibration Report

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

High-Throughput Phenotyping Protocols (HTPP), WP3

Kampala, Uganda, 29/11/2022

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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-mashed roots, while sensory data was collected from cooked roots.

Place: Uganda

Date: 29/11/2022

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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 (R^2 = 0.92) and dry matter (R^2 = 0.71), suggesting that the model is sufficient for field application. The moderate performances of models for sweetpotato aroma, pumpkin aroma and flavor, hardness by hand, fracturability, moisture in mass and mealiness by hand (R^2 > 0.50) could be used for initial screening purposes. Most of the calibrations still need improvement.

Key Words: NIRS, Sweet potato, sensorial profiles, Calibrations, chemometrics, textural quality

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-mashed 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-mashed sweetpotato roots

#	Parameter	N	Mean	SD	Minimum	Maximum
1	Sweetpotato aroma	353	5.7	1.4	0.2	8.1
2	Caramel aroma	353	0.4	0.3	0	1.5
3	Pumpkin aroma	353	0.5	0.6	0	3.3
4	Off odour	353	0.3	1.2	0	8.2
5	Orange color intensity	353	4.8	3	0.1	9.2
6	Uniformity of color	353	7.2	1.4	0.5	9.6
7	Degree of transluscency	353	1	0.6	0.1	3.9
8	Fibrous appearance	353	1.1	1.1	0.2	6.8
9	Sweetpotato flavor	353	5.7	1.6	0.1	8.2
10	Pumpkin flavor	353	0.6	0.7	0	3
11	Cooked carrot flavor	353	0.1	0.2	0	1.4
12	Floral flavor	353	0.3	1	0	6.3
13	Sweet taste	353	5.4	1.6	0	7.7
14	Bitter taste	353	0.2	0.9	0	7.3
15	Hardness by hand	353	4.6	1.9	0.2	8.8
16	Moisture release	353	1	1.6	0	7.7
17	Cohesiveness	353	5.4	2.6	0.2	9.3
18	Crumbliness/Mealiness by hand	353	4.8	2.4	0.6	9.3
19	Fracturability	353	4	2.3	0.3	8.3

#	Parameter	N	Mean	SD	Minimum	Maximum
20	Firmness/ Hardness	353	3.9	1.6	0	7.8
21	Crunchiness	353	0.6	0.6	0	4.3
22	Moisture in mass	353	4.3	2.2	0.3	8.9
23	Crumbliness	353	4.6	2.4	0.2	8.7
24	Adhessiveness (Stickiness)	353	1.6	0.6	0.4	3.4
25	Fibrousness	353	0.9	1.3	0	7.9
26	Smoothness	353	6.5	1.6	1.6	9.5
27	Rate of breakdown	341	5.9	1.4	2.1	8.8
28	Dry matter	341	36.5	6.5	17.8	46.6
29	Peak positive force 1	332	5217	2362	1474	12709
30	Peak positive force 2	332	3624	1541	1097	8272
31	Positive Area 1	332	9468	3925	2734	18384
32	Positive Area 2	332	3525	1689	1022	8524
33	Optimal cooking time	183	23.2	9.5	10	55
34	Water absorption1	300	1.4	2.1	-5.1	7.4
35	Water absorption2	117	2.3	2.3	-2.5	7.7

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.

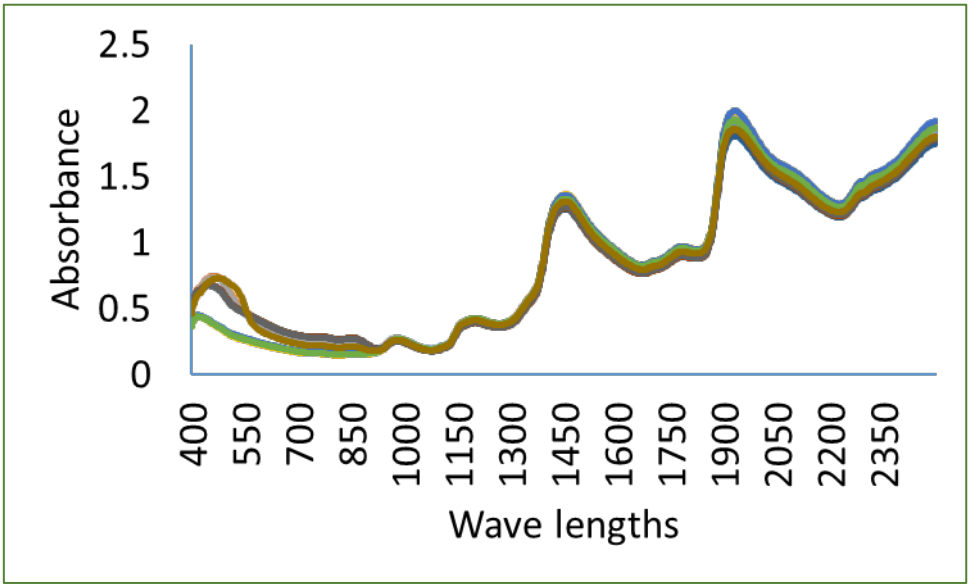

Figure 1 : NIRS spectra of raw-mashed sweetpotato

2.1.2 Spectra: Principal Components Analysis

A PCA calculated on the spectra (spectral range NIR) of the samples shows that 91% of variance 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 especially in Namulonge (Figure 2) appeared to be distant from the others. Similarly, some samples collected in 2021, seemed to be distant from the clusters (Figure 3).

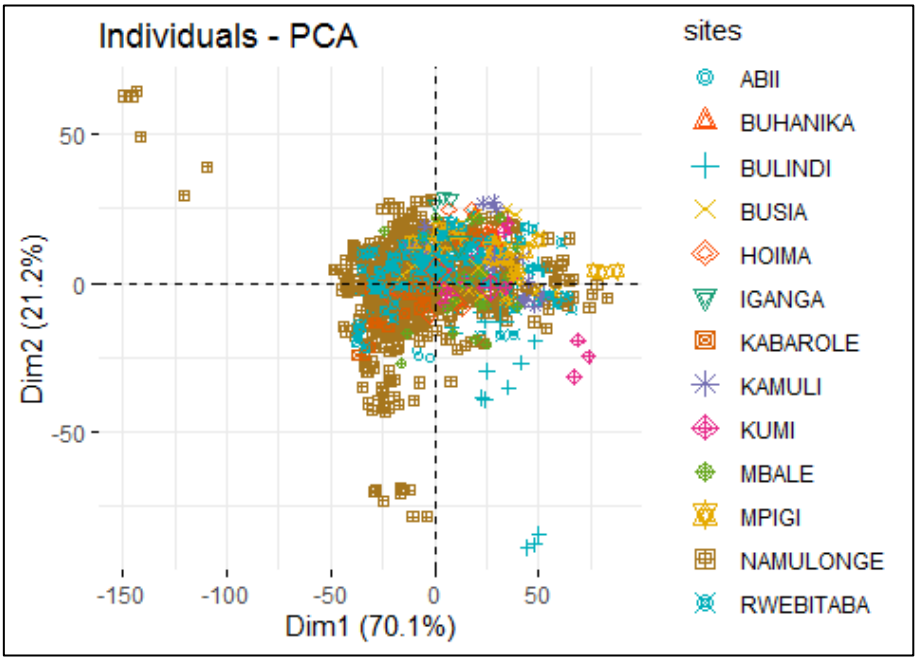

Figure 2 : PCA plot of the raw-mashed spectra collected from different sites

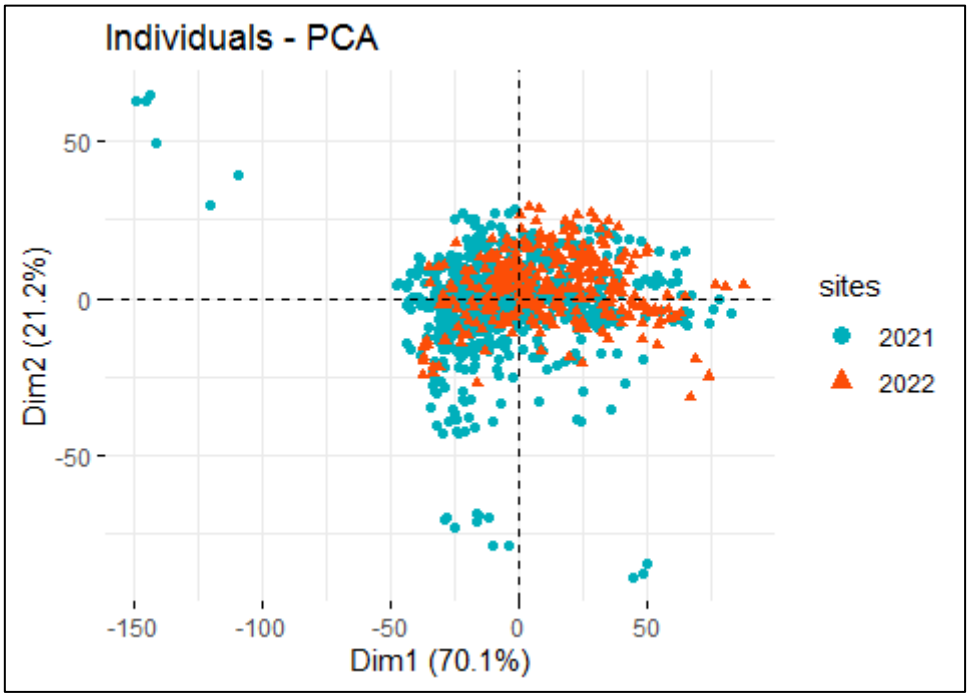

Figure 3 : PCA plot of the raw-mashed spectra collected from different seasons

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-mashed roots

#	Parameter	R^2	SECV	# components
1	Sweetpotato aroma	0.52	0.73	5
2	Caramel aroma	0.21	0.30	6
3	Pumpkin aroma	0.60	0.42	5
4	Off odor	0.09	0.12	7
5	Orange color intensity	0.92	0.84	7
6	Uniformity of color	0.25	0.86	7
7	degree of translucency	0.23	0.52	3
8	Fibrous appearance	0.09	0.61	4
9	Sweetpotato flavor	0.33	1.11	7
10	Pumpkin flavor	0.63	0.42	7
11	Cooked carrot flavor	0.18	0.21	3
12	Floral flavor	0.14	0.15	7
13	Sweet taste	0.13	1.25	7
14	Bitter taste	0.13	0.07	7
15	Hardness by hand	0.51	1.26	7
16	Moisture release	0.43	0.98	7
17	Cohessiveness	0.44	1.94	7
18	Mealiness by hand	0.57	1.60	6
19	Fractrability	0.57	1.59	6
20	Firmness/Hardness	0.52	1.05	7
21	Crunchiness	0.20	0.38	6
22	Moisture in mass	0.66	1.34	7
23	Crumbliness	0.63	1.49	6
24	Adhessiveness	0.15	0.53	7
25	Fibrousness	0.19	0.58	5
26	Smoothness	0.43	1.23	7
27	Rate of breakdown	0.51	0.95	7
28	Dry matter	0.71	3.48	7
29	Peak positive force 1	0.39	1843	7
30	Peak positive force 2	0.45	1126	7
31	Positive Area 1	0.47	2823	6
32	Positive Area 2	0.39	1365	7
33	Optimal cooking time	0.32	7.43	7
34	Water absorption	0.24	1.85	4
35	Water absorption2	0.34	1.92	6

2.1.4 Statistics parameters for calibrations:

High performances were observed of the calibration for orange color intensity (R^2 =0.92) and dry matter (R^2 =0.71), suggesting that the model is sufficient for field application. Moderate model performances for swetpotato aroma, flavor, moisture in mass, mealiness among others (R^2 > 0.50) were detected. Most of the calibrations still need improvement (R^2< 0.50). Similar performance on external validation was detected for orange color intensity (R^2 =0.91) and dry matter (R^2 =0.70). Consistent with the calibration models, the validation models for sweetpotato aroma, pumpkin flavor, hardness by hand, fracturability, moisture in mass and mealiness by hand were moderate (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	0.50	0.73
2	Caramel aroma	0.08	0.29
3	Pumpkin aroma	0.48	0.44
4	Off odor	0.01	0.10
5	Orange color intensity	0.91	0.94
6	Uniformity of color	0.33	0.92
7	degree of translucency	0.19	0.59
8	Fibrous appearance	0.00	0.44
9	Sweetpotato flavor	0.29	1.13
10	Pumpkin flavor	0.52	0.45
11	Cooked carrot flavor	0.11	0.14
12	Floral flavor	0.01	0.20
13	Sweet taste	0.23	1.30
14	Bitter taste	0.04	0.10
15	Hardness by hand	0.61	1.27
16	Moisture release	0.50	1.10
17	Cohessiveness	0.39	2.22
18	Mealiness by hand	0.75	1.31
19	Fracturability	0.58	1.47
20	Firmness/Hardness	0.44	1.29
21	Crunchiness	0.16	0.45
22	Moisture in mass	0.73	1.26
23	Crumbliness	0.51	1.60
24	Adhessiveness	0.11	0.58
25	Fibrousness	0.13	0.58
26	Smoothness	0.43	1.56
27	Rate of breakdown	0.52	1.04
28	Dry matter	0.70	3.10
29	Peak positive force 1	0.51	1723
30	Peak positive force 2	0.31	1425
31	Positive Area 1	0.55	2610
32	Positive Area 2	0.55	1121
33	Optimal cooking time	0.30	7.33
34	Water absorption	0.18	1.97
35	Water absorption2	0.16	2.15

3 CONCLUSION

NIRS shows some potential to predict selected sensory parameters such as orange color intensity and dry matter. 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.

Classification approaches can be investigated according to sensorial classes based on individual traits or combined traits. A acceptability threshold can be defined and classification methods based on spectral fingerprints can be investigated such as PLSDA, KNN, SVM, SIMCA among others.

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