Calibration Report

NIRS Analyses of Sensory & Textural Traits in Sweetpotato based on Spectra Collected on Cooked 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 = 0.91) and dry matter, suggesting that the model is sufficient for field application. The moderate performances of pumpkin aroma, pumpkin flavor, cohesiveness, mealiness by hand, fracturability, crumbliness, aroma and moisture in mass (R^2 > 0.50) could be used for initial screening purposes. Most of the calibrations still need improvement.

Key words: Cooked sweet potato, sensorial profiles, textural porperties, NIRS, calibrations, chemometrics

1 DATA

1.1 Material

A total of 217 genotypes were collected from different CIP sweetpotato genetic trials (GT) located in different agroecological zones (AEZ); West Nile AEZ (Abii GT; L. Albert AEZ (Hoima and Bulindi 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 panelists 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 cooked-mashed sweetpotato roots

#	Parameter	N	Mean	SD	Minimum	Maximum
1	Sweetpotato aroma	598	5.56	1.6	0	8.11
2	Caramel aroma	598	0.37	0.36	0	2.77
3	Pumpkin aroma	598	0.36	0.56	0	3.96
4	Off odour	598	0.42	1.36	0	8.33
5	Orange color intensity	598	4.26	2.96	0	9.18
6	Uniformity of color	598	6.86	1.71	0.45	9.64
7	Degree of transluscency	598	1.04	0.57	0	3.86
8	Fibrous appearance	598	1.18	1.34	0	7
9	Sweetpotato flavor	598	5.6	1.76	0	8.25
10	Pumpkin flavor	598	0.47	0.7	0	5.9
11	Cooked carrot flavor	598	0.1	0.19	0	1.44
12	Floral flavor	598	0.42	1.27	0	6.42
13	Sweet taste	598	5.09	1.75	0	7.55
14	Bitter taste	598	0.3	1.07	0	7.25
15	Hardness by hand	598	4.34	1.76	0.17	8.78
16	Moisture release	598	1.05	1.83	0	8.08
17	Cohesiveness	598	5.68	2.41	0.2	9.33
18	Crumbliness/Mealiness by hand	598	4.86	2.34	0.33	9.25

#	Parameter	N	Mean	SD	Minimum	Maximum
19	Fracturability	598	3.88	2.06	0.27	8.25
20	Firmness/ Hardness	598	3.69	1.55	0	7.78
21	Crunchiness	598	0.66	0.98	0	6.42
22	Moisture in mass	598	4.33	2.09	0.3	8.86
23	Crumbliness	598	4.6	2.33	0.2	8.67
24	Adhessiveness (Stickiness)	598	1.38	0.58	0	3.37
25	Fibrousness	598	1.06	1.66	0	8.33
26	Smoothness	598	6.61	1.44	1.63	9.45
27	Rate of breakdown	574	6.68	4.64	2.13	39.77
28	Dry matter	562	36.15	5.52	17.82	46.62
29	Peak positive force 1	544	4790	2175	1473	12709
30	Peak positive force 2	544	3395	1444	1097	8272
31	Positive Area 1	544	8662	3671	2716	18384
32	Positive Area 2	556	3257	1649	25	8524
33	Optimal cooking time	371	21.55	8.77	-0.24	55
34	Water absorption1	467	1.4	2.14	-5.07	7.92
35	Water absorption2	108	2.44	2.38	-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.

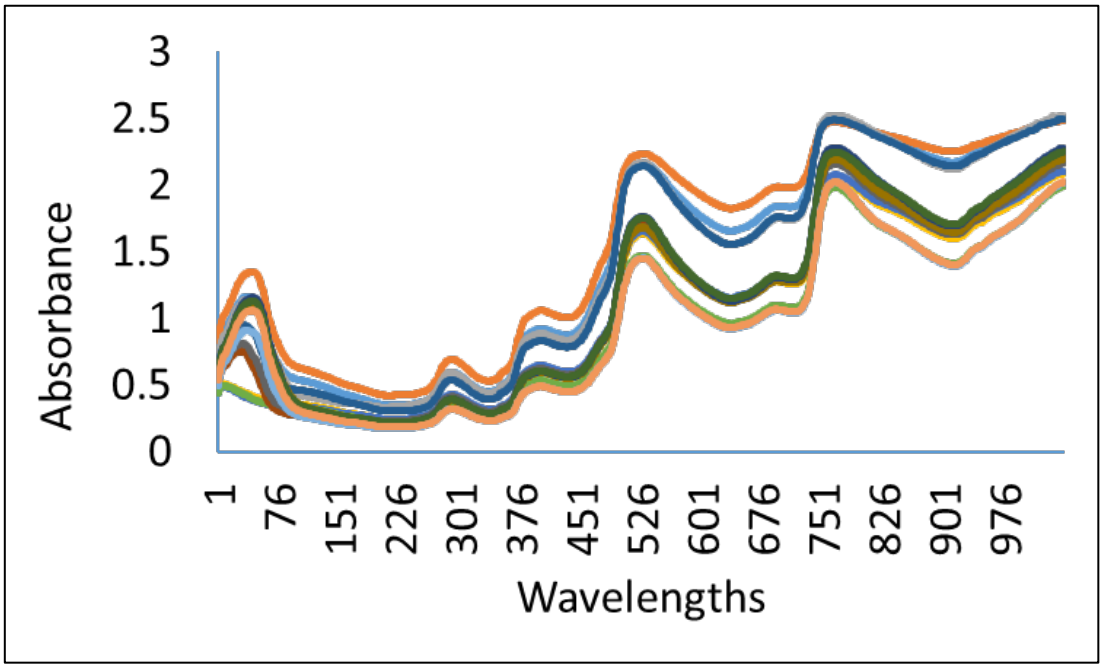

Figure 1 : NIRS spectra of cooked-mashed sweetpotato

Spectra: Principal Components Analysis

A PCA calculated on the spectra (spectral range NIR) of the samples shows that 92% of variance explained by the 2 first PCs. This indicated that cooked mashed samples are more homogenous than the raw-mashed or intact samples. However, 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).

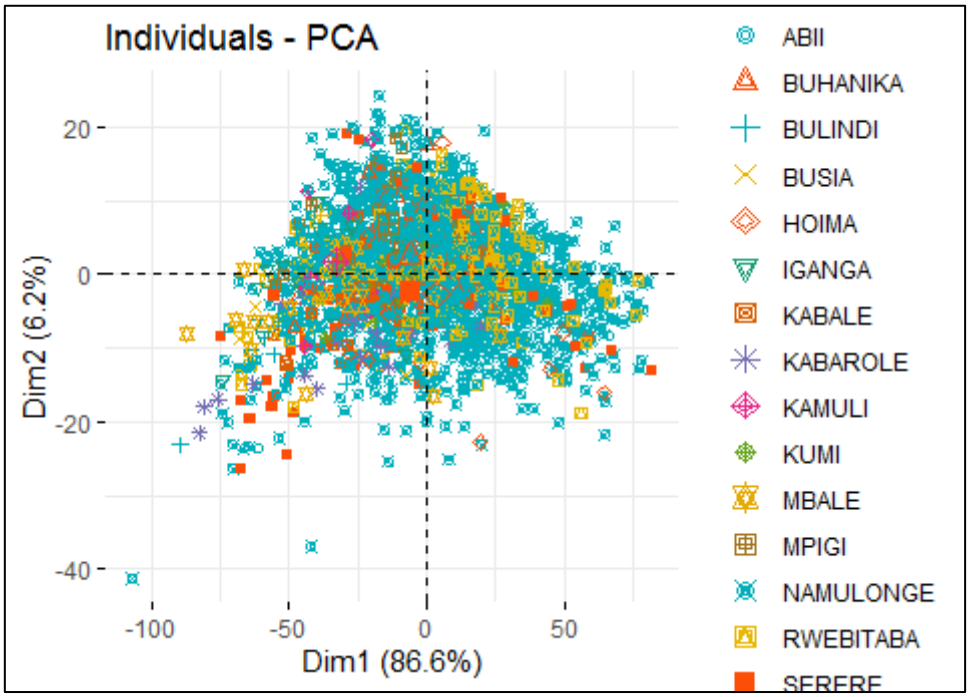

Figure 2 : PCA plot of the cooked-mashed spectra collected from different sites

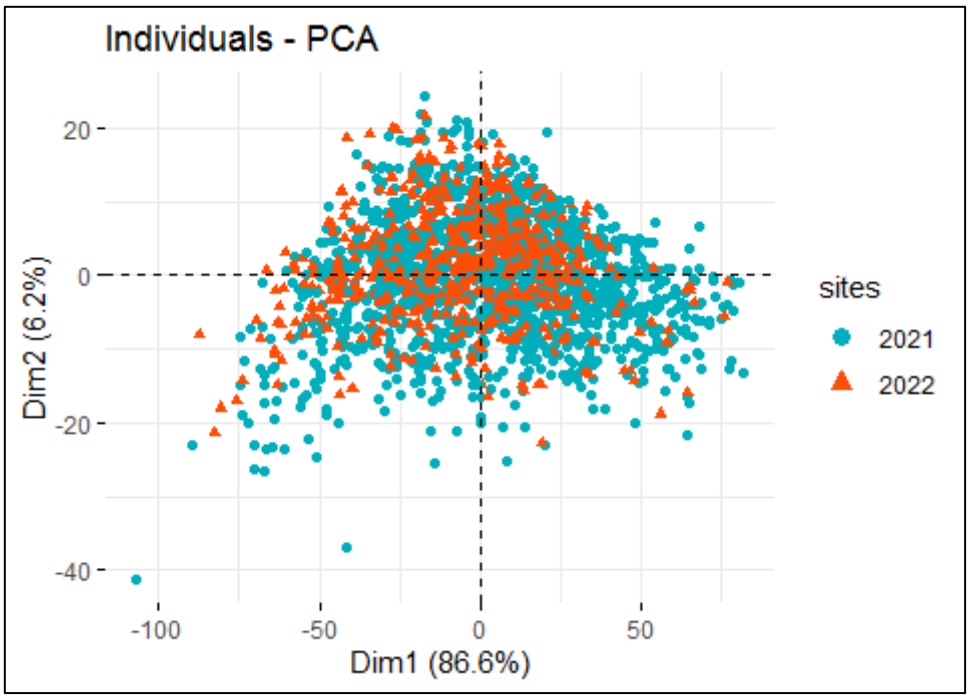

Figure 3 : PCA plot of the cooked-mashed spectra collected from different seasons

2.1.2 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 cooked-mashed roots

#	Parameter	R^2	SECV	# components
1	Sweetpotato aroma	0.5	0.8	5
2	Caramel aroma	0.2	0.29	7
3	Pumpkin aroma	0.6	0.35	6
4	Off odor	0	0.52	1
5	Orange color intensity	0.9	0.88	7
6	Uniformity of color	0.3	1.07	6
7	degree of translucency	0.3	0.51	7
8	Fibrous appearance	0.1	0.63	7
9	Sweetpotato flavor	0.4	1.03	7
10	Pumpkin flavor	0.6	0.42	6
11	Cooked carrot flavor	0.2	0.18	5
12	Floral flavor	0.1	0.24	6
13	Sweet taste	0.4	1.09	7
14	Bitter taste	0.1	0.31	1
15	Hardness by hand	0.5	1.28	7
16	Moisture release	0.5	1	6
17	Cohessiveness	0.5	1.88	7
18	Mealiness by hand	0.7	1.43	7
19	Fracturability	0.6	1.47	7
20	Firmness/Hardness	0.5	1.04	7
21	Crunchiness	0.2	0.38	6
22	Moisture in mass	0.7	1.34	7
23	Crumbliness	0.7	1.44	7
24	Adhessiveness	0	0.57	1
25	Fibrousness	0.1	0.79	7
26	Smoothness	0.5	1.22	7
27	Rate of breakdown	0.4	1.95	1
28	Dry matter	0.3	167	1
29	Peak positive force 1	0.4	2331	7
30	Peak positive force 2	0.4	1646	7
31	Positive Area 1	0.3	2997	7
32	Positive Area 2	0.3	1303	7
33	Optimal cooking time	0.2	8.1	2
34	Water absorption	0.3	1.87	7
35	Water absorption2	0.2	2.05	5

2.1.3 Statistics parameters for calibrations:

High performances were observed of the calibration for orange color intensity (R^2 =0.91), suggesting that the model is sufficient for field application. Moderate performances for pumpkin aroma, pumpkin flavor, cohesiveness, mealiness by hand, fracturability, crumbliness, aroma and moisture in mass (R^2 > 0.50) were detected. Most of the calibrations still need improvement (R^2< 0.50). The external validation model for orange color intensity (R^2 =0.92) was still robust (Table 3). The models of mealiness by hand, fracturability, firmness, crumbliness and moisture in mass were consistent with the calibration robustness.

Table 3: NIRS predictions performances for the sensory parameters of sweetpotato. Test set of cooked mashed samples.

#	Parameter	R^2	SEP
1	Sweetpotato aroma	0.3	1.04
2	Caramel aroma	0.2	0.26
3	Pumpkin aroma	0.4	0.41
4	Off odor	0	0.15
5	Orange color intensity	0.9	0.92
6	Uniformity of color	0.4	0.92
7	degree of translucency	0.3	0.47
8	Fibrous appearance	0	0.7
9	Sweetpotato flavor	0.5	1.03
10	Pumpkin flavor	0.4	0.43
11	Cooked carrot flavor	0.2	0.21
12	Floral flavor	0.1	0.32
13	Sweet taste	0.4	1.12
14	Bitter taste	0	0.73
15	Hardness by hand	0.5	1.38
16	Moisture release	0.2	1.03
17	Cohessiveness	0.6	1.69
18	Mealiness by hand	0.7	1.44
19	Fractrability	0.6	1.56
20	Firmness/Hardness	0.4	1.24
21	Crunchiness	0.3	0.39
22	Moisture in mass	0.6	1.46
23	Crumbliness	0.7	1.23
24	Adhessiveness	0	0.52
25	Fibrousness	0.1	0.86
26	Smoothness	0.4	1.27
27	Rate of breakdown	0	3.63
28	Dry matter	0	427
29	Peak positive force 1	0.4	2829
30	Peak positive force 2	0.5	1633
31	Positive Area 1	0.4	2570
32	Positive Area 2	0.3	1561
33	Optimal cooking time	0.2	7.11
34	Water absorption	0.1	2.51
35	Water absorption2	0.2	2.84

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.

4 REFERENCES

Nakitto M (2020) SOP for sensory evaluation on boiled sweetpotato. Biophysical characterization of quality traits, WP2.

Nakitto M, Johanningsmeier SD*, et al.* (2022) Sensory guided selection criteria for breeding consumer-preferred sweetpotatoes in Uganda. *Food Quality and Preference* **101**, 104628.

Nantongo SJ, Serunkuma, Edwin, Burgos, Gabriela, Devrieux Fabrice, Meghar K, Ssali Reuben (2022) SOP for near infrared spectroscopy (NIRS) acquisition on sweetpotato roots and potato tubers. *WP3, DOI:10.18167/agritrop/00708*.

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