Calibration Report

NIRS Analyses of Sensory & Textural Traits in Sweetpotato based on Spectra Collected on Cooked Freeze-Dried

High-Throughput Phenotyping Protocols (HTPP), WP3

Kampala, Uganda, 29/11/2022

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This report has been written in the framework of RTBfoods project.

To be cited as:

Judith S NANTONGO, Edwin SERUNKUMA, Gabriela BURGOS, Fabrice DAVRIEUX, Karima MEGHAR, Reuben SSALI (2023). *NIRS Analyses of Sensory & Textural Traits in Sweetpotato based on Spectra Collected on Cooked Freeze-Dried; High-Throughput Phenotyping Protocols (HTPP), WP3.* Kampala, Uganda: RTBfoods Calibration Report, 10 p. https://doi.org/10.18167/agritrop/00729

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.

Acknowledgments: This work was supported by the RTBfoods project https://rtbfoods.cirad.fr, through a grant OPP1178942: Breeding RTB products for end user preferences (RTBfoods), to the French Agricultural Research Centre for International Development (CIRAD), Montpellier, France, by the Bill & Melinda Gates Foundation (BMGF).
The authors also acknowledge other CIP colleagues, Grisom Bwire, Rose Makumbi, James Kawuma and Joseph Kitalikyawe involved in sweetpotato work. The support staff in the NIRS lab; Esther Lyaga, Joyce Akot, Dorothy Naluwooza, Prossy Nakiwu and Milly Nakirya are very appreciated.

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ABSTRACT

Context: This scientific report concerns NIRS calibrations of sweetpotato sensory traits. The spectral data were collected from cooked freeze-dried 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 = 0.80), suggesting that the model is sufficient for field application. The moderate performances of sweet taste, uniformity of color, fibrousness, pumpkin flavor, pumpkin aroma, moisture release and hardness (R^2 > 0.50) could be used for initial screening purposes. Most of the calibrations still need improvement.

Key words: NIRS, cooked sweet potato, sensorial profiles, textural properties, 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 freeze-dried roots for spectral analysis is detailed in the standard operating procedure on NIR spectra collection (Nantongo 2022). However, this data analysis is based on a partial dataset.

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 raw freeze-dried sweetpotato roots

#	Parameter	N	Mean	SD	Minimum	Maximum
1	Sweetpotato aroma	100	4.63	2.5	0.17	7.4
2	Caramel aroma	100	0.37	0.39	0	1.42
3	Pumpkin aroma	100	0.17	0.48	0	2.55
4	Off odour	100	1.56	2.71	0	8.33
5	Orange color intensity	100	3.17	2.93	0	9.18
6	Uniformity of color	100	5.96	2.65	0.45	9.27
7	Degree of transluscency	100	1.06	0.6	0.13	3.25
8	Fibrous appearance	100	1.98	2.33	0	6.83
9	Sweetpotato flavor	100	4.7	2.71	0.08	8.18
10	Pumpkin flavor	100	0.2	0.49	0	2.5
11	Cooked carrot flavor	100	0.04	0.11	0	0.55
12	Floral flavor	100	1.37	2.38	0	6.42
13	Sweet taste	100	3.95	2.54	0	7.55
14	Bitter taste	100	1.14	2.02	0	7.25
15	Hardness by hand	100	3.65	2.11	0.17	8.3
16	Moisture release	100	1.8	2.72	0	8.08
17	Cohesiveness	100	5.13	2.56	0.3	9.18
18	Crumbliness/Mealiness by hand	100	5.58	2.27	0.5	8.8
19	Fracturability	100	4.55	2.18	0.27	8.13

#	Parameter	N	Mean	SD	Minimum	Maximum
20	Firmness/ Hardness	100	3.12	1.99	0	7
21	Crunchiness	100	1.19	1.55	0	6.42
22	Moisture in mass	100	3.71	2.07	0.5	8.7
23	Crumbliness	100	4.74	2.67	0.2	8
24	Adhessiveness (Stickiness)	100	1.37	0.52	0.56	2.5
25	Fibrousness	100	2.04	2.86	0	8.33
26	Smoothness	100	6.46	1.55	1.67	9.45
27	Rate of breakdown	76	6.02	1.41	2.22	8.8
28	Dry matter	76	37.58	5.07	24.99	45.27
29	Peak positive force 1	76	4833	2190	1694	9475
30	Peak positive force 2	76	3490	1559	1380	6946
31	Positive Area 1	76	8858	4151	2948	18384
32	Positive Area 2	76	3617	1831	1270	7907
33	Optimal cooking time	39	22.05	4.96	15	40
34	Water absorption1	76	1.06	1.93	-4.72	4.62
35	Water absorption2	26	1.66	2.24	-1.97	5.63

2 RESULTS

2.1 Near Infrared Spectroscopy

2.1.1 Exploration

The spectra patterns are depicted in Figure 1. The spectra seem to differ from the fresh samples.

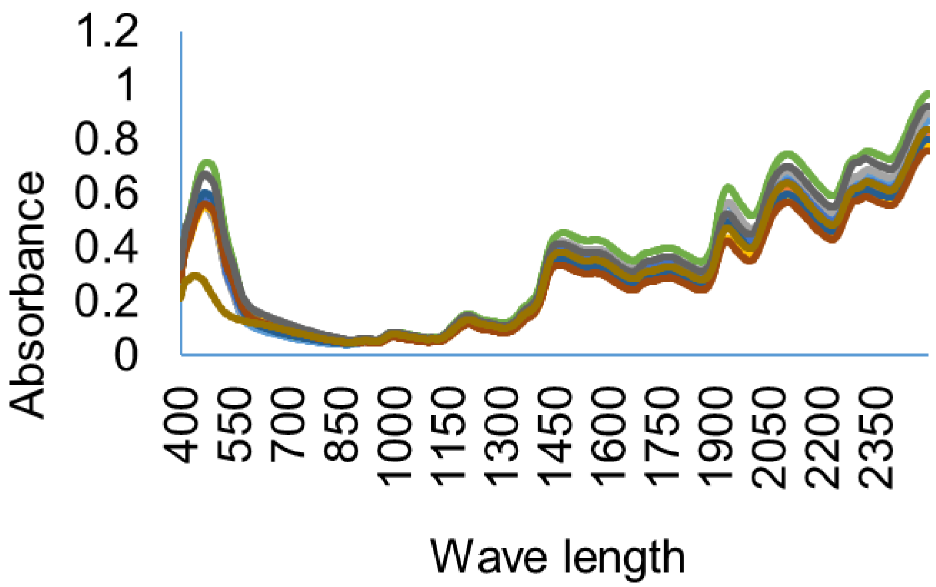

Figure 1 : NIRS spectra of cooked freeze-dried sweetpotato

2.1.2 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. The spectra from Namulonge (Figure 2) appeared to be distant from the others.

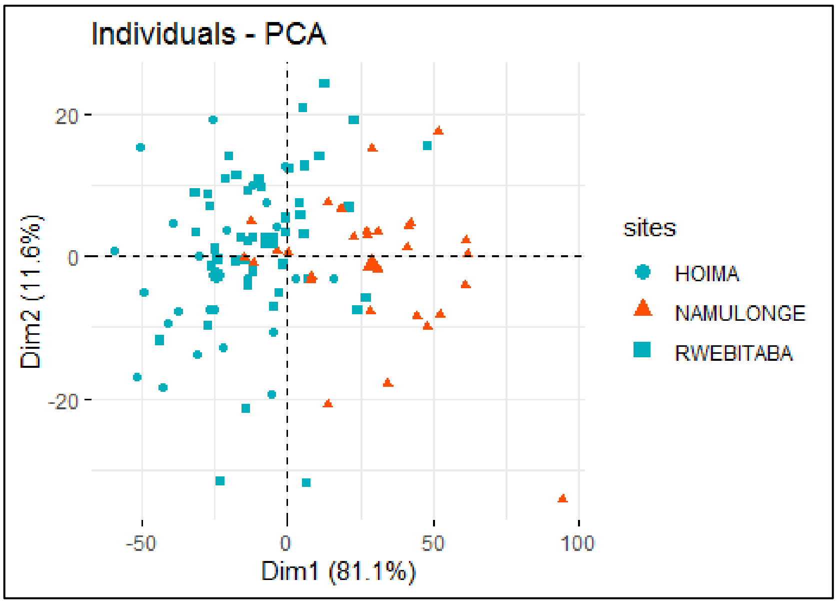

Figure 2 : PCA plot of spectra collected from cooked freeze-dried samples of different sites

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). A maximum of 4 components were allowed due to a limited sample size. All samples were used to train the model and no external validation was made.

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 freeze-dried roots. A maximum of 4 components were allowed. Optimal cooked time and the 2nd water absorption were not included due to very small sample size.

#	Parameter	R²	SECV	# components
1	Sweetpotato aroma	0.6	1.84	4
2	Caramel aroma	0.2	0.36	3
3	Pumpkin aroma	0.5	0.29	4
4	Off odor	0.6	1.82	4
5	Orange color intensity	0.8	1.32	4
6	Uniformity of color	0.7	1.73	4
7	degree of translucency	0.3	0.52	4
8	Fibrous appearance	0.6	1.71	4
9	Sweetpotato flavor	0.6	1.9	4
10	Pumpkin flavor	0.5	0.34	4
12	Floral flavor	0.6	1.77	4
13	Sweet taste	0.6	1.77	4
14	Bitter taste	0.6	1.47	4
15	Hardness by hand	0.5	1.59	3
16	Moisture release	0.6	2	4
17	Cohessiveness	0.4	2.32	4
18	Mealiness by hand	0.6	1.65	4
19	Fractrability	0.5	1.68	4
20	Firmness/Hardness	0.7	1.29	4

#	Parameter	R^2	SECV	# components
21	Crunchiness	0.5	1.19	4
22	Moisture in mass	0.4	1.78	4
23	Crumbliness	0.5	2.01	3
24	Adhessiveness	0.4	0.45	4
25	Fibrousness	0.5	2.07	4
26	Smoothness	0.4	1.26	4
27	Rate of breakdown	0.5	1.17	2
28	Dry matter	0.4	4.38	2
29	Peak positive force 1	0.4	1966	1
30	Peak positive force 2	0.4	1369	1
31	Positive Area 1	0.5	3650	1
32	Positive Area 2	0.5	1644	1
34	Water absorption	0.5	1.46	1

2.1.4 Statistics parameters for calibrations:

High performances were observed of the calibration for orange color intensity (R^2 =0.80), suggesting that the model is sufficient for field application. Moderate performances for sweet taste, uniformity of color, fibrousness, pumpkin flavor, pumpkin aroma, moisture release and hardness (R^2 > 0.50) were detected. Most of the calibrations still need improvement (R^2< 0.50).

3 CONCLUSION

NIRS shows some potential to predict selected sensory parameters such as orange color intensity. However, most of the calibrations are still poor and may be improved by adding additional samples, especially to minimise the seasonality effect.

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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