Nigerian Journal of Physics (NJP)
ISSN online: 3027-0936
ISSN print: 1595-0611
DOI: https://doi.org/10.62292/njp.v35(s).2026.794
Volume 35(S), November 2026

Ultraviolet to Near-Infrared Absorbance Spectra of Aqueous Extracts of Four Yam (*Dioscorea* spp.) Cultivars from the Benue Valley, Nigeria: A Preliminary Spectrophotometric Study

***Terwase Aondona Isaac[1], Shiaondo Tsavnande Lazarus[1], Terwase Victor Sesugh[2], Amool Shagbaor Hycent[3], Nyityo Aondona Israel[4], Guusu Msughter Joseph[4], Oranderen Matthew Mzough[5], Lumun Terkuma Caleb[6], and Ikyo Barnabas[1]**

[1]Center for Food Technology and Research (CEFTER), Benue State University, Makurdi, Nigeria
[2]Department of Mathematics and Computer Science, Benue State University, Makurdi, Nigeria
[3]Department of Agricultural and Environmental Engineering, Joseph Sarwuan Tarka University, Makurdi, Nigeria
[4]Department of Physics, Joseph Sarwuan Tarka University, Makurdi, Nigeria
[5]Department of Applied Geophysics, University of Calabar, Calabar, Nigeria
[6]Department of Electrical and Electronics Engineering, Joseph Sarwuan Tarka University, Makurdi, Nigeria

*Corresponding Author's Email: aondonatwas@gmail.com

Keywords:
Yam,
Dioscorea,
UV-Vis Spectrophotometry,
Aqueous Extract,
Absorbance Spectra,
Storage Age,
Benue Valley

Submitted: 05/11/2026

Accepted: 16/11/2026

Published:25/11/2026

ABSTRACT

Yam (*Dioscorea* spp.) is a staple crop of the Benue Valley, Nigeria, but no ultraviolet to near-infrared absorbance data exist for its local cultivars. This preliminary study measured absorbance spectra (190 to 1000 nm) of aqueous extracts of four cultivars, *Anasue*, *Fakentsa*, *Hembakwase* and Water yam. One tuber of each cultivar was taken at each of three storage ages (1, 4 and 7 months), giving twelve specimens. Peeled slices about 2 mm thick were soaked in distilled water for 72 hours and the filtrates were scanned against a distilled-water blank. Each extract was scanned once, so the results are descriptive. All twelve extracts shared one spectral shape: a maximum at 222 to 227 nm (absorbance 3.11 to 3.65), a shoulder between about 255 and 275 nm, a steep fall between 280 and 320 nm, a smooth decline through the visible region and low absorbance between 700 and 800 nm (mean 0.17 to 0.61). Readings above 3 correspond to less than 0.1% transmission and are treated as semi-quantitative. Mean absorbance from 240 to 280 nm ranged from 2.04 to 3.12 and did not differ significantly among cultivars (ANOVA, $p = 0.78$) or storage ages ($p = 0.29$). The spectra describe water-soluble extract constituents.

INTRODUCTION

Yam (*Dioscorea* spp.) is one of the most important root and tuber crops of West Africa. It supplies calories to millions of people, carries cultural weight in many communities and supports a large market economy (Asiedu and Sartie, 2010, Obidiegwu et al., 2020). Benue State hosts the Zaki-Biam yam market, widely reported as the largest in the world, and local cultivars such as *Anasue*, *Fakentsa*, *Hembakwase* and Water yam are grown across the Benue Valley. Storage life of the harvested tuber is governed largely by dormancy and sprouting (Craufurd et al., 2001), and the composition of the tuber changes as it is held. Spectroscopic records of that composition for local cultivars are scarce.

Ultraviolet-visible (UV-Vis) absorption spectroscopy of extracts is a long-established first step for detecting soluble chromophores in plant and food materials, and UV spectral fingerprints are now used in food quality control (Farag et al., 2022). The method suits the water-soluble fraction of yam tubers for a practical reason. That fraction contains the storage protein dioscorin (Nagai and Nagashima, 2006), phenolic compounds and, in coloured *D. alata*, anthocyanins (Srivichai and Hongsprabhas, 2020, Rinaldo et al., 2022), together with the polyphenol oxidase and peroxidase enzymes that generate browning products (Okpuzor and Omidiji, 1998, Graham-Acquaah et al., 2014). These classes absorb in different regions. Aromatic amino acid residues in proteins absorb near 280 nm (Pace et al.,

1995), phenolics absorb in the near ultraviolet, anthocyanins absorb in the visible region near 520 nm (Giusti and Wrolstad, 2001) and oxidised phenolic products add absorbance across the visible region (Queiroz et al., 2008). An aqueous-extract spectrum therefore sums several constituents, and a change in its shape or level signals a change in extractable composition. Water is inexpensive and safe, and it recovers hydrophilic constituents only. The spectrum depends on extraction time, temperature and solvent (Spigno et al., 2007, Dai and Mumper, 2010, Alara et al., 2021), and fine suspended particles scatter light and raise apparent absorbance (Wormell and Rodger, 2013). An extract spectrum is thus an operationally defined measurement of the extract and not a property of the intact tuber.

Published optical work on tubers addresses intact tissue and other crops. Optical properties and light transport have been measured and modelled for potato (Xiao et al., 2023, López-Maestresalas et al., 2016) and onion (Chugunov and Li, 2015), and these studies are summarised in reviews of Monte Carlo methods and tissue optics (Jacques, 2013, Hu et al., 2020). For yam, spectroscopy has mainly meant near-infrared reflectance calibrations for composition and quality traits (Lebot and Malapa, 2013, Alamu et al., 2020), and UV-Vis has been used for phenolic and anthocyanin assays in purple *D. alata* (Srivichai and Hongsprabhas, 2020). UV-visible spectrophotometry of plant-derived dyes and starch-based preparations has appeared in this journal (Okoye et al., 2021, Tasi'u et al., 2025), but we found no report of ultraviolet to near-infrared absorbance spectra of aqueous yam extracts for Benue Valley cultivars, or of how such spectra vary with the storage age of the tuber. That is the gap this study addresses.

The objectives were to (i) record the 190 to 1000 nm absorbance spectra of aqueous extracts of four Benue Valley yam cultivars taken at three storage ages, (ii) describe each of the twelve spectra with numerical descriptors, (iii) establish which spectral regions are reliable given high-absorbance and instrumental effects, and (iv) compare cultivars and storage ages with appropriate statistics. Measurements were made on extracts. Tissue-level optical properties are outside the scope of this paper.

MATERIALS AND METHODS

Sampling, identification and specimen numbering

Four locally named cultivars, *Anasue* (A), *Fakentsa* (FT), *Hembakwase* (HK) and Water yam (WY), were purchased from the Zaki-Biam yam market, Benue State, Nigeria. At the market the tubers had been held for 1, 4 or 7 months after harvest in the storage systems locally available to traders. The tubers selected were fresh and neatly stored and in good physical condition. One tuber was taken for each combination of cultivar and storage age, giving three tubers per cultivar and twelve specimens in total (Table 1, Figure 1a). Each specimen is therefore an independently sourced tuber. The numerals in the specimen codes are the storage age in months (for example A1, A4 and A7 are *Anasue* tubers held for 1, 4 and 7 months), and they are not replicate numbers.

Cultivars were identified by the vernacular names given by the traders who supplied them and they are some of the most common yam cultivers within the Benue valley. Water yam corresponds to *D. alata* in local usage. The botanical species of the three Tiv-named cultivars was not verified by morphological keys or molecular markers, and no voucher specimens were deposited. The twelve-specimen design reflects tuber availability and laboratory access and was not based on a power calculation, so it supports description of spectral features but not estimation of cultivar means. The tubers were transported to the research laboratory at The Polytechnic, Ibadan, where all preparation and measurement took place. It took 120 hours from the last sample collection to the final analysis on the spectrophotometer.

Table 1: Specimen key. One tuber was sampled for each cultivar and storage age.

Cultivar (local name)	Specimen codes	Storage age (months)	Basis of identification
Anasue	A1, A4, A7	1, 4, 7	Vernacular name
Fakentsa	FT1, FT4, FT7	1, 4, 7	Vernacular name
Hembakwase	HK1, HK4, HK7	1, 4, 7	Vernacular name
Water yam	WY1, WY4, WY7	1, 4, 7	Vernacular name (*D. alata* in local usage)

Extract preparation

Each tuber was peeled and cut into slices about 2 mm thick and the middle part of the tuber was used because from observation, it is the richest part of the yam, rarely subjected to spoilage during harvesting. 2g of 10 slices were placed in a clean standard glass beaker of 250mL and fully immersed in 100mL of distilled water (sample-to-water ratio of 0.02 g/mL). The beakers stood for 72 hours at ambient laboratory temperature of about 25 to 29 °C. No antioxidant, preservative or enzyme inhibitor was added, and the mixtures were not stirred or heated. After soaking, the liquid was separated from the slices

with a funnel and Whatman No. 1 filter paper and transferred to labelled vials. The extracts were visibly yellow (Figure 1b). The soaking time was identical for all specimens, which keeps conditions uniform across the set. A 72-hour.



Figure 1: Sample material. (a) Tubers of the four cultivars. (b) Peeled slices of Water yam tubers aged 1, 4 and 7 months immersed in distilled water during extraction.

Spectrophotometric measurement

Absorbance spectra were recorded in transmission with a Cecil Aurius Series CE 2021 multilingual, 4 nm bandwidth, single beam UV spectrophotometer from 190 to 1000 nm (with a Littrow monochromator and a 1200 L/mm holographic grating). Extracts were held in quartz cuvettes of 10mm optical path length. The instrument was warmed up for 30 before use, and water blank was recorded and stored as the reference, with each extract scanned once. Absorbance was calculated as

$$A(\lambda) = log_{10}\left(\frac{I_0(\lambda)}{I(\lambda)}\right) = -log_{10}T(\lambda) \quad (1)$$

where λ is the wavelength, $I_0(\lambda)$ is the intensity transmitted by the distilled-water blank, $I(\lambda)$ is the intensity transmitted by the extract and $T(\lambda)$ is the transmittance, which follows as

$$T(\lambda) = \frac{I(\lambda)}{I_0(\lambda)} = 10^{-A(\lambda)} \quad (2)$$

Under the Beer-Lambert law the absorbance of a non-scattering solution is also $A = \varepsilon cl$, with ε the molar absorption coefficient, c the concentration and l the path length (Swinehart, 1962). An absorbance of 3.0 corresponds to a transmittance of 0.1%, and 3.65 corresponds to 0.022%.

Spectral descriptors and statistics

Each spectrum was reduced to numerical descriptors with a script, so that every specimen is described by the same quantities. The descriptors were the maximum absorbance (A_{max}) and its wavelength (λ_{max}) between 190 and 400 nm, the width $W_{2.5}$ (the wavelength span over which the smoothed absorbance stays at or above 2.5 between 190 and 320 nm), the mean absorbance from 240 to 280 nm (a plateau region free of the sharp maximum), the absorbance at 300, 400, 500 and 700 nm (7-point running median), the mean absorbance from 400 to 700 nm (visible) and the mean absorbance from 700 to 800 nm. Comparisons in the near-infrared region were restricted to 700 to 800 nm because scatter and recurring artefacts increase above 800 nm.

Cultivar (four levels, three specimens each) and storage age (three levels, four specimens each) were tested separately by one-way analysis of variance, with the Kruskal-Wallis test as a distribution-free check and a significance level of 0.05. Because each combination of cultivar and storage age is a single tuber, tuber-to-tuber variation cannot be separated from the cultivar or age effect and their interaction cannot be estimated. As a simple additional measure, the mean range of the three specimens within each cultivar was compared with the range of the four cultivar means.

RESULTS AND DISCUSSION

Data quality and the interpretable range

Readings above an absorbance of about 3 correspond to a transmitted intensity under 0.1% of the blank. At that level stray light, detector noise and baseline drift dominate, and the linear relation between absorbance and concentration fails (Swinehart, 1962, Mäntele and Deniz, 2017). Stray light usually makes recorded absorbance lower than the true value at high absorbance, and low signal adds random scatter (Wormell and Rodger, 2013).

A narrow maximum appears at 222 to 227 nm in all twelve spectra (Figure 2a). Its height (3.11 to 3.65) varies far less than the surrounding plateau (2.04 to 3.12 between 240 and 280 nm). A feature that recurs at the same wavelength in extracts of different composition is more plausibly instrumental than chemical. Comparisons between specimens therefore use the broader plateau region and not the sharp maximum.

The spectra above 800 nm carry excursions of up to about 0.1 absorbance units that recur at the same wavelengths in the spectra (near 820, 878 to 883, 912, 980 and 989 nm, Figure 2b). Recurrence across extracts of different composition points to an instrumental origin.

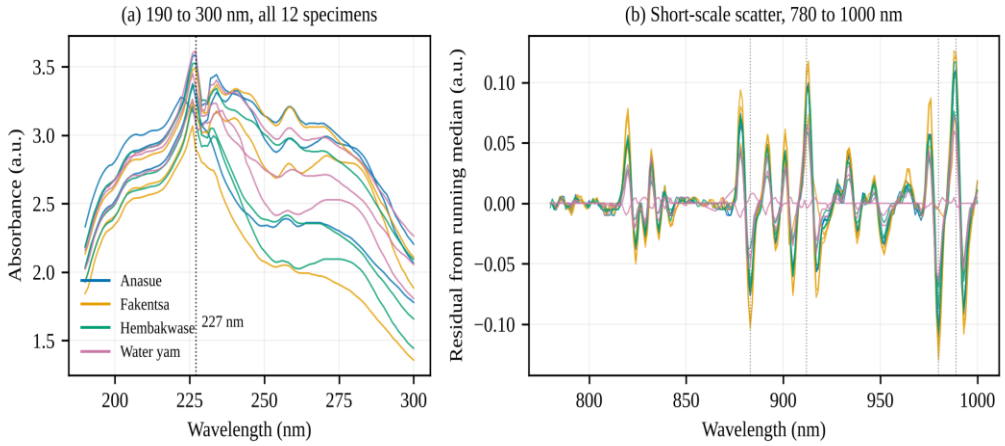

Figure 2: Data-quality features of the twelve spectra. (a) The 190 to 300 nm region, with the common maximum at 227 nm marked. (b) Residuals from a 25-point running median between 780 and 1000 nm, with the recurring excursions marked by dotted lines.

Common spectral shape

All twelve extracts share one shape as depicted in Figure 3. Absorbance rises from 190 nm to a maximum at 222 to 227 nm and stays high across a plateau from about 240 to 280 nm, where most specimens show a shoulder or secondary maximum between about 255 and 275 nm. It then falls steeply between 280 and 320 nm, to 1.36 to 2.26 at 300 nm. Through the visible region the decline is smooth and monotonic, with absorbance at 400, 500 and 700 nm of 0.67 to 1.43, 0.41 to 0.96 and 0.19 to 0.65. Between 700 and 800 nm the mean absorbance is 0.17 to 0.61 shown in Table 2.

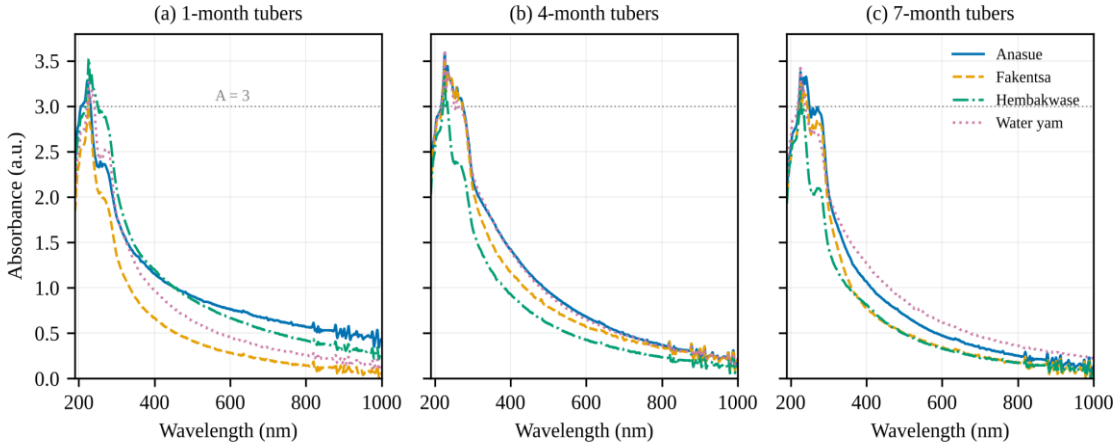

Figure 3: Absorbance spectra of aqueous extracts of the four cultivars, grouped by storage age: (a) 1 month, (b) 4 months and (c) 7 months. Each curve is a single scan of one extract. The dotted line marks an absorbance of 3.

The strong absorbance below 300 nm is consistent with proteins, aromatic amino acid residues, phenolic compounds and other conjugated molecules, which absorb strongly there (Pace et al., 1995, Farag et al.,

2022). The shoulder near 255 to 275 nm and the smooth visible tail fit a mixture of such species with some coloured oxidation products (Queiroz et al., 2008). The smooth decline with wavelength in the visible and near-infrared regions is also what weak absorption plus scattering by fine suspended particles would produce, and the two contributions cannot be separated (Jacques, 2013, Wormell and Rodger, 2013).

Table 2: Spectral descriptors of the twelve extract spectra. A_{max} and λ_{max} are the maximum and its wavelength (190 to 400 nm), $W_{2.5}$ is the span with absorbance at or above 2.5, and A_n is the absorbance at *n* nm. Values are absorbance units unless stated.

Specimen	A_{max}	λ_{max} (nm)	$W_{2.5}$ (nm)	Mean *A*, 240–280 nm	A_{300}	A_{400}	A_{500}	A_{700}	Mean *A*, 400–700 nm	Mean *A*, 700–800 nm
A1	3.27	222	49	2.36	1.78	1.16	0.91	0.65	0.85	0.61
A4	3.65	227	97	3.12	2.21	1.43	0.96	0.49	0.85	0.43
A7	3.49	227	90	3.00	2.06	1.07	0.70	0.34	0.62	0.29
FT1	3.11	226	33	2.04	1.36	0.67	0.41	0.19	0.37	0.17
FT4	3.57	227	93	3.11	2.11	1.17	0.79	0.43	0.71	0.39
FT7	3.38	227	84	2.83	1.89	0.78	0.50	0.24	0.45	0.21
HK1	3.63	227	92	2.94	2.09	1.20	0.87	0.52	0.79	0.47
HK4	3.39	227	43	2.38	1.66	0.93	0.60	0.31	0.54	0.27
HK7	3.31	227	39	2.15	1.44	0.81	0.49	0.23	0.44	0.20
WY1	3.28	226	78	2.55	1.81	0.97	0.63	0.33	0.57	0.30
WY4	3.63	227	101	3.03	2.27	1.41	0.92	0.48	0.83	0.42
WY7	3.58	227	88	2.74	2.06	1.27	0.86	0.47	0.77	0.41

Differences between cultivars

The spectra do not rank the cultivars. The highest maximum (3.65) occurred in *Anasue* A4 and the lowest (3.11) in *Fakentsa* FT1, and the range of maxima within each cultivar overlaps those of the others (Table 2). The cultivar means of the maximum absorbance were 3.47, 3.36, 3.45 and 3.49 for *Anasue*, *Fakentsa*, *Hembakwase* and Water yam, with no significant difference (ANOVA $p = 0.83$). The plateau absorbance (240 to 280 nm) gave the same result ($p = 0.77$), as did the absorbance at 300 nm ($p = 0.51$), the visible mean ($p = 0.24$) and the 700 to 800 nm mean ($p = 0.35$). The Kruskal-Wallis test agreed in every case ($p = 0.17$ to 0.79). Peak width does not separate the cultivars either, since $W_{2.5}$ ranged from 33 nm (FT1) to 101 nm (WY4) and varied as much within each cultivar as between them.

The variation among tubers of one cultivar was larger than the variation among cultivar means for all five descriptors. For the plateau absorbance the mean within-cultivar range was 0.77 against 0.33 for the range of cultivar means, and for the maximum absorbance the figures were 0.38 and 0.14. With three tubers per cultivar the tests have little power, so the absence of a significant difference does not prove that the cultivars are optically alike. The data do not support a claim of cultivar-specific spectra, and they show that a single spectrum cannot represent a cultivar.

Table 3: Group means ± standard deviation of five descriptors by cultivar and by storage age, with test results. Each group mean combines specimens that differ in the other factor.

Group	Maximum *A*	Mean *A*, 240–280 nm	A_{300}	Mean *A*, 400–700 nm	Mean *A*, 700–800 nm
Anasue (*n* = 3)	3.47 ± 0.19	2.83 ± 0.41	2.02 ± 0.22	0.77 ± 0.14	0.45 ± 0.16
Fakentsa (*n* = 3)	3.36 ± 0.23	2.66 ± 0.56	1.78 ± 0.39	0.51 ± 0.18	0.25 ± 0.11
Hembakwase (*n* = 3)	3.45 ± 0.17	2.49 ± 0.41	1.73 ± 0.33	0.59 ± 0.18	0.32 ± 0.14
Water yam (*n* = 3)	3.49 ± 0.19	2.77 ± 0.24	2.04 ± 0.23	0.72 ± 0.13	0.37 ± 0.07
ANOVA *p* (Kruskal-Wallis *p*), cultivar	0.83 (0.79)	0.77 (0.72)	0.51 (0.62)	0.24 (0.17)	0.35 (0.29)
1 month (*n* = 4)	3.32 ± 0.22	2.47 ± 0.38	1.76 ± 0.30	0.65 ± 0.22	0.39 ± 0.19
4 months (*n* = 4)	3.56 ± 0.12	2.91 ± 0.35	2.06 ± 0.27	0.74 ± 0.14	0.38 ± 0.07
7 months (*n* = 4)	3.44 ± 0.12	2.68 ± 0.37	1.86 ± 0.29	0.57 ± 0.16	0.28 ± 0.10
ANOVA *p* (Kruskal-Wallis *p*), storage age	0.16 (0.17)	0.29 (0.14)	0.37 (0.22)	0.44 (0.39)	0.47 (0.40)

Differences between storage ages

In *Anasue*, *Fakentsa* and Water yam the 4-month tuber had the highest plateau and visible absorbance, and in *Hembakwase* the 1-month tuber was highest and absorbance fell with age. Absorbance between 700 and 800 nm fell with age in *Anasue* (0.61, 0.43, 0.30) and *Hembakwase* (0.47, 0.27, 0.20) but not in *Fakentsa* or Water yam. None of the five descriptors differed significantly among the three storage ages ($p = 0.16$ to 0.47). Because each cell of the design is one tuber, any age effect is confounded with tuber-to-tuber differences in maturity, handling and the part of the tuber sampled, which is known to vary in phenolic content (Graham-Acquaah et al., 2014). Phenolic and anthocyanin contents of yam tubers also change as the tuber develops (Srivichai and Hongsprabhas, 2020). The present data cannot attribute the differences to storage age, and a design with several independent tubers per cultivar and age is needed to test it.

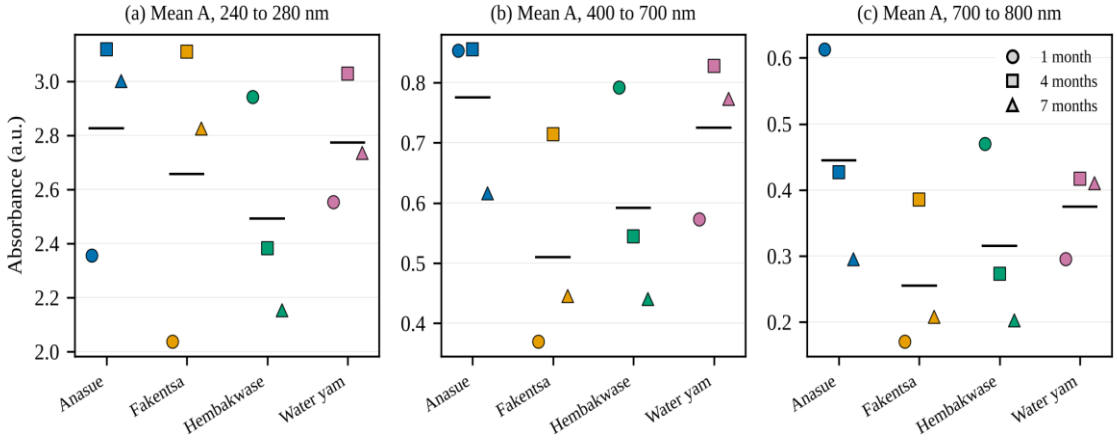

Figure 4: Descriptor values for each specimen: (a) mean absorbance from 240 to 280 nm, (b) from 400 to 700 nm and (c) from 700 to 800 nm. Colours identify the cultivar, marker shapes identify the storage age and horizontal bars mark cultivar means.

What the spectra do and do not show

The central limitation is that the measurements describe water-soluble material extracted from yam slices over 72 hours. They do not describe the optical behaviour of intact tubers, which scatter light strongly and absorb differently from a clarified solution (Xiao et al., 2023, Jacques, 2013), and in which photon penetration depends on wavelength and measurement geometry (Zhang et al., 2016). Statements about light penetration or transmission through whole tubers would need tissue-level measurements and are not made here.

Two applications are often proposed for spectra of this kind, and neither is demonstrated. Strong ultraviolet absorbance by an extract does not show that ultraviolet radiation accelerates deterioration of stored tubers, or that ultraviolet-blocking storage lighting or packaging extends shelf life. No irradiation or storage trial was done. A controlled storage experiment with and without ultraviolet filtering, recording weight loss, sprouting and browning, would test the idea. In the same way, low absorbance of an aqueous extract above 700 nm does not show that the near-infrared region is suited to non-destructive sensing of intact tubers. That would require near-infrared reflectance or transmission measurements on tissue, building on existing yam calibrations (Lebot and Malapa, 2013, Alamu et al., 2020). Both applications are presented as subjects for future research and not as implications of the present results.

Limitations and validation needed

The following limitations bound every conclusion above.

- Each extract was scanned once on one instrument. No replicate scans, independent extractions, procedural blanks beyond distilled water, or baseline stability checks were recorded, and no uncertainty can be attached to the descriptors.
- Readings above an absorbance of about 3 are semi-quantitative, and no dilution series or linearity check was made.
- The 72-hour soak was not controlled against enzymatic browning, oxidation or microbial change, and the extraction ratio, temperature and clarification were not optimised or standardised.
- Each cultivar-and-age cell is one tuber, so storage age, tuber identity and sampling position are confounded.
- Cultivars were identified by vernacular names only.
- No chemical assay (total phenolics, protein, turbidity) was run, so the assignments of absorbance to compound classes are interpretations.

CONCLUSION

This preliminary study recorded single-scan absorbance spectra of aqueous extracts of twelve yam tubers (four Benue Valley cultivars at storage ages of 1, 4 and 7 months). The main findings are limited to the observed spectral patterns of those extracts.

- All extracts share one shape, with a maximum at 222 to 227 nm (absorbance 3.11 to 3.65), a plateau and shoulder between 240 and 280 nm, a steep fall to 320 nm and a smooth decline to 0.17 to 0.61 between 700 and 800 nm.
- The cultivars cannot be ranked. Within-cultivar variation exceeded between-cultivar differences in all five descriptors, and no descriptor differed significantly among cultivars or storage ages (all $p \geq 0.16$).
- Light-protective storage and near-infrared sensing were not tested and remain topics for future work.

This study establishes the spectral features of the extracts and the range over which they can be read reliably. Extending it with replicate measurements and controlled extraction will allow reference spectra to be built.

Acknowledgement

We thank the sponsors, the World Bank Africa Centers of Excellence (ACE) Impact Award through the Center for Food Technology and Research (CEFTER), and Benue State University, Makurdi. This paper is derived from the first author's M.Sc. dissertation (Benue State University, Makurdi, 2026).

Sources of Funding

The research was funded by the World Bank Africa Centers of Excellence (ACE) Impact Award through the Center for Food Technology and Research (CEFTER), and Benue State University, Makurdi.

Data Availability

The absorbance spectra used to compute the descriptors are available from the corresponding author on request.

REFERENCES

Alamu, E. O., Adesokan, M., Asfaw, A., & Maziya-Dixon, B. (2020). Effect of sample preparation methods on the prediction performances of near infrared reflectance spectroscopy for quality traits of fresh yam (*Dioscorea* spp.). *Applied Sciences*, 10(17), 6035. https://doi.org/10.3390/app10176035

Alara, O. R., Abdurahman, N. H., & Ukaegbu, C. I. (2021). Extraction of phenolic compounds: A review. *Current Research in Food Science*, 4, 200–214. https://doi.org/10.1016/j.crfs.2021.03.011

Asiedu, R., & Sartie, A. (2010). Crops that feed the world 1. Yams. *Food Security*, 2(4), 305–315. https://doi.org/10.1007/s12571-010-0085-0

Chugunov, S., & Li, C. (2015). Monte Carlo simulation of light propagation in healthy and diseased onion bulbs with multiple layers. *Computers and Electronics in Agriculture*, 117, 91–101. https://doi.org/10.1016/j.compag.2015.07.015

Craufurd, P. Q., Summerfield, R. J., Asiedu, R., & Vara Prasad, P. V. (2001). Dormancy in yams. *Experimental Agriculture*, 37(2), 147–181. https://doi.org/10.1017/S001447970100206X

Dai, J., & Mumper, R. J. (2010). Plant phenolics: Extraction, analysis and their antioxidant and anticancer properties. *Molecules*, 15(10), 7313–7352. https://doi.org/10.3390/molecules15107313

Farag, M. A., Sheashea, M., Zhao, C., & Maamoun, A. A. (2022). UV fingerprinting approaches for quality control analyses of food and functional food coupled to chemometrics: A comprehensive analysis of novel trends and applications. *Foods*, 11(18), 2867. https://doi.org/10.3390/foods11182867

Giusti, M. M., & Wrolstad, R. E. (2001). Characterization and measurement of anthocyanins by UV-visible spectroscopy. *Current Protocols in Food Analytical Chemistry*, Unit F1.2. https://doi.org/10.1002/0471142913.faf0102s00

Graham-Acquaah, S., Ayernor, G. S., Bediako-Amoa, B., Saalia, F. K., & Afoakwa, E. O. (2014). Spatial distribution of total phenolic content, enzymatic activities and browning in white yam (*Dioscorea rotundata*) tubers. *Journal of Food Science and Technology*, 51(10), 2833–2838. https://doi.org/10.1007/s13197-012-0760-6

Hu, D., Sun, T., Yao, L., Yang, Z., Wang, A., & Ying, Y. (2020). Monte Carlo: A flexible and accurate technique for modeling light transport in food and agricultural products. *Trends in Food Science & Technology*, 102, 280–290. https://doi.org/10.1016/j.tifs.2020.05.006

Jacques, S. L. (2013). Optical properties of biological tissues: A review. *Physics in Medicine and Biology*, 58(11), R37–R61. https://doi.org/10.1088/0031-9155/58/11/R37

Lebot, V., & Malapa, R. (2013). Application of near infrared reflectance spectroscopy for the evaluation of yam (*Dioscorea alata*) germplasm and breeding lines.

Journal of the Science of Food and Agriculture, 93(7), 1788–1797. https://doi.org/10.1002/jsfa.6002

López-Maestresalas, A., Aernouts, B., Van Beers, R., Arazuri, S., Jarén, C., De Baerdemaeker, J., & Saeys, W. (2016). Bulk optical properties of potato flesh in the 500–1900 nm range. *Food and Bioprocess Technology*, 9(3), 463–470. https://doi.org/10.1007/s11947-015-1639-0

Mäntele, W., & Deniz, E. (2017). UV–VIS absorption spectroscopy: Lambert-Beer reloaded. *Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy*, 173, 965–968. https://doi.org/10.1016/j.saa.2016.09.037

Nagai, T., & Nagashima, T. (2006). Functional properties of dioscorin, a soluble viscous protein from Japanese yam (*Dioscorea opposita* Thunb.) tuber mucilage tororo. *Zeitschrift für Naturforschung C*, 61(11–12), 792–798. https://doi.org/10.1515/znc-2006-11-1204

Obidiegwu, J. E., Lyons, J. B., & Chilaka, C. A. (2020). The *Dioscorea* genus (yam): An appraisal of nutritional and therapeutic potentials. *Foods*, 9(9), 1304. https://doi.org/10.3390/foods9091304

Okoye, I. F., Alaekwe, I. O., & Abba, O. (2021). UV-VIS spectrophotometer analysis of film grown using natural dye from *Lawsonia inermis* (henna plant). *Nigerian Journal of Physics*, 30(2), 135–139. https://njp.nipngr.org/index.php/njp/article/view/104

Okpuzor, J., & Omidiji, O. (1998). Peroxidase-polyphenol oxidase association in *Dioscorea esculenta*. *Zeitschrift für Naturforschung C*, 53(11–12), 957–960. https://doi.org/10.1515/znc-1998-11-1204

Pace, C. N., Vajdos, F., Fee, L., Grimsley, G., & Gray, T. (1995). How to measure and predict the molar absorption coefficient of a protein. *Protein Science*, 4(11), 2411–2423. https://doi.org/10.1002/pro.5560041120

Queiroz, C., Mendes Lopes, M. L., Fialho, E., & Valente-Mesquita, V. L. (2008). Polyphenol oxidase: Characteristics and mechanisms of browning control. *Food Reviews International*, 24(4), 361–375. https://doi.org/10.1080/87559120802089332

Rinaldo, D., Sotin, H., Pétro, D., Le-Bail, G., & Guyot, S. (2022). Browning susceptibility of new hybrids of yam (*Dioscorea alata*) as related to their total phenolic content and their phenolic profile determined using LC-UV-MS. *LWT*, 162, 113410. https://doi.org/10.1016/j.lwt.2022.113410

Spigno, G., Tramelli, L., & De Faveri, D. M. (2007). Effects of extraction time, temperature and solvent on concentration and antioxidant activity of grape marc phenolics. *Journal of Food Engineering*, 81(1), 200–208. https://doi.org/10.1016/j.jfoodeng.2006.10.021

Srivichai, S., & Hongsprabhas, P. (2020). Profiling anthocyanins in Thai purple yams (*Dioscorea alata* L.). *International Journal of Food Science*, 2020, 1594291. https://doi.org/10.1155/2020/1594291

Swinehart, D. F. (1962). The Beer-Lambert law. *Journal of Chemical Education*, 39(7), 333. https://doi.org/10.1021/ed039p333

Tasi'u, J., Onimisi, M. Y., & Danladi, E. (2025). Influence of reaction time on the optical properties of silver nanoparticles synthesized using soluble starch. *Nigerian Journal of Physics*, 34(1), 154–158. https://njp.nipngr.org/index.php/njp/article/view/362

Wormell, P., & Rodger, A. (2013). Absorbance spectroscopy: Spectral artifacts and other sources of error. In *Encyclopedia of Biophysics* (pp. 26–29). Springer. https://doi.org/10.1007/978-3-642-16712-6_776

Xiao, Z., Xu, Y., Wang, X., Wang, Y., Cheng, M., Liu, S., & Qu, J. (2023). Optical properties and Monte Carlo multi-layered simulation of potato skin and flesh tissues. *Postharvest Biology and Technology*, 205, 112488. https://doi.org/10.1016/j.postharvbio.2023.112488

Zhang, H., Salo, D. C., Kim, D. M., Komarov, S., Tai, Y. C., & Berezin, M. Y. (2016). Penetration depth of photons in biological tissues from hyperspectral imaging in shortwave infrared in transmission and reflection geometries. *Journal of Biomedical Optics*, 21(12), 126006. https://doi.org/10.1117/1.JBO.21.12.126006