Eco. Env. & Cons. 29 (April Suppl. Issue) : 2023; pp. (S175-S180)
Copyright@ EM International
ISSN 0971–765X

DOI No.: http://doi.org/10.53550/EEC.2023.v29i02s.033

Functional Compound Changes during Postharvest Physiological Deterioration of Cassava Tuber

Sowmya Priya, S.* and Kalarani, M.K.

Department of Crop Physiology, Tamil Nadu Agricultural University, Coimbatore, T.N., India

(Received 10 September, 2022; Accepted 18 November, 2022)

ABSTRACT

Reducing the economic value of the cassava tuber crop, thereby Postharvest Physiological Deterioration (PPD) is the major problem in cassava that renders the tuber unmarketable. After harvest of cassava tuber causing fluorescence in the storage parenchyma was observed, because changes in metabolic compound mainly responsible for the fluorescence. Its content peaks within 24 hours of injury and prior to the development of the visual symptoms of physiological deterioration. The present study of Fourier infrared transform spectroscopy (FTIR) was performed with CI 850, YTP 1, H740/92 and H226 cassava genotypes to identify the functional compound changes during Postharvest Physiological Deterioration. FTIR spectroscopy is a technique based on the determination of the interaction between infrared (IR) radiation and a sample. The present study revealed that the extracts of fresh cassava tuber and stored tubers of different cassava genotypes, has potential to produce bioactive functional compounds like hydrocarbons, oxygen compounds, nitrogen containing compounds, isocyanates, thiocyanide, cyanide, isothiocyanates, oxidized nitrogen functions, sulfur compounds, phosphorous and amides but their quantity was differently in cassava genotypes which correlate with reinforcement of tolerance to PPD under storage condition.

Key words : *Postharvest Physiological Deterioration, Fourier infrared transform spectroscopy, Genotypes, Functional compounds*

Introduction

Cassava (*Manihot esculenta*) is cultivated as an annual crop in tropical and subtropical regions for its edible starchy, tuberous root. Cassava is the third largest source of food carbohydrates in the tropics, after rice and maize. Cassava is a major staple food in the developing world, providing a basic diet for over half a billion people. It is one of the most drought-tolerant crops, capable of growing on marginal soils.

However, subsistence and commercial utilization of cassava are affected by its short shelf-life due to a rapid postharvest physiological deterioration (PPD). PPD in cassava is rapid, begins within 24 to 48 h after harvest and can result in losses in the range of 15 to 30 per cent of the total expected economic value of the crop. PPD is an oxidative reaction that starts immediately after harvesting when the tuber is detached from the mother plant. It resembles typical changes associated with the plants response to wounding. Physiological and biochemical changes during PPD include increases in respiration (Sanchez *et al*., 2013), mobilisation of starch to sugars and changes in lipid composition (Lalaguna and Agudo, 1989). Also, accumulation of scopoletin is more pronounced in cassava cultivars that are more responsible for the fluorescence in the storage parenchyma observed after cutting cassava. Its content peaks within 24 hours of injury and prior to the development of the visual symptoms of physiological deterioration (Wheatley and Schwabe, 1985). Fur-

thermore, the accumulation of biochemical compounds are more pronounced in cassava cultivars that are more susceptible or tolerant to PPD, decreasing after 6 days due to lower metabolism changes. This study has provided evidence that Postharvest Physiological Deterioration is associated with functional compound accumulation and expressed differently in cassava genotypes which correlate with tolerance to PPD under storage condition.

Materials and Methods

Plant material

Four cassava genotypes *viz.,* CI 850, YTP 1, H740/92 and H226 were collected from Tapioca and Castor Research Station, Yethapur, Salem, Tamil Nadu, India. Cassava tubers from twelve month old plants were harvested by digging the rhizosphere area and used for PPD evaluation.

Fourier infrared Trans form spectroscopy (FTIR)

Infrared spectroscopy allows the analysis of physiological changes during postharvest physiological deterioration. Samples of fresh tuber from immediately after harvest and 5 days after harvest were collected for analysis. An FT/IR - 6800 (JASCO FT/IR – 6800, Made in Japan) spectrometer with a DTGS detector equipped with a golden gate single reflection diamond attenuated total reflectance (ATR) accessory (45^{o} incidence angle) was used. A background spectrum of the clean crystal was acquired and samples (100 mg) were spread and measured directly after they were pressed on the crystal. The spectra were recorded in transmittance mode over a spectral window from 4000 to 400 cm^{-1} at a resolution of 4 cm^{-1}. Five replicate spectra (128 co-added scans before Fourier transform) were collected for each sample, in a total of 80 spectra.

Results and Discussion

FTIR spectroscopy is a technique based on the determination of the interaction between infrared (IR) radiation and a sample. Elucidation of the molecular structure is especially important in organic chemistry. An analytical method for the identification of functional groups from organic compounds uses one of the most physical properties of a chemical compound in the infrared absorption spectrum. The FTIR spectroscopic investigation revealed that different characteristic peaks with various functional compounds in the cassava tuber extracts. The FTIR analysis of extracts of fresh and stored tubers of different cassava genotypes, confirmed the presence of hydrocarbons, oxygen compounds, nitrogen compounds, isocyanates, isothiocyanates, oxidized nitrogen functions, sulfur compounds, phosphorous and amides (alcohols, phenols, alkanes, carboxylic acids, aldehydes, ketones, alkenes, primary amines, aromatics, esters, ethers, alkyl halides and aliphatic amines compounds) showed their major peaks. The result of FTIR analysis indicated that the spectral regions associated with different functional compounds which are given in Table 67. The extract of cassava genotype CI 850 fresh tuber exhibited a characteristic peak at 3772.08 to 3987.82 cm^{-1} indicating the presence of a alcohol group, at 3344.93 cm^{-1}, 3249.47 cm^{-1} for strong alcohol, 2768.66, 2751.72, 2734.46 cm^{-1} for alkyne, carboxylic acid respectively. 2208.09 to 1889.9 cm^{-1} for thiocyanate, isothiocyanate and isocyanate, 1636 cm^{-1} for oxime group, 1736 cm^{-1} for N aldehyde group, 1066.44 cm^{-1} for amines, 1211.08 cm^{-1} for ester, 1272.79 cm^{-1} for aromatic, 13366.33 cm^{-1} for phenol, 1506.13 cm^{-1} for nitro compound and 538.42 to 406.07 cm^{-1} for sulfur and phosphorous compounds. These peaks were similarly observed in other genotypes also. Irrespective of the genotypes, peak at 1900 to 2250 cm^{-1} was observed which represent thiocyanate, isothiocyanate and isocyanate in all the genotypes of fresh and stored tuber but number of peaks was expressed differently. Among the genotypes CI 850 produced 12 and 17 peaks (1889 to 2188 cm^{-1}) at the same time H226 was produced 21 and 24 peaks (1890 to 2297 cm^{-1}) of fresh and stored tubers respectively. YTP 1 produced 16 and 20 (1888 to 2175 cm^{-1}) and H740/92 expressed 15 and 22 peaks (1889 to 2208 cm^{-1}) in the same spectral region of fresh and stored tubers respectively. Peak at 946 cm^{-1} was observed in all the genotypes of fresh and stored tubers which represent presence of HCN in the tuber extracts.

Strong skeletal bands for isocyanates, isothiocyanates, diamides, azides and ketenes fall in the 1900 to 2250 cm^{-1} region of the spectrum. These skeletal bands arise from the stretching of the carbon -nitrogen bonds in the ring structure. This cyanide is distributed widely throughout the cassava tuber, with large amounts in the leaves and the tuber cortex (skin layer) and generally smaller amounts in the tuber parenchyma (interior). The bitter taste of cas-

Table 1. FTIR spectral peak values and functional groups obtained for the selected cassava genotypes

Class	Group	Wavenumber (cm^{-1})	CI 850FT (cm^{-1})	CI 8505 DAS(cm^{-1})	YTP 1FT (cm^{-1})	YTP 15 DAS (cm^{-1})	H740/92 FT (cm^{-1})	H740/925 DAS(cm^{-1})	H226FT (cm^{-1})	H2265 DAS (cm^{-1})
Aromatic	C=C	1450-1600	1510.95	1516.74	1508.06	1516.74	1506.58	1506.13	1510.95	1516.74
Alkene	C=C	1630-1670	1635.34	1638.60	1636.33	1637.27	1636.32	1638.54	1638.23	1636.33
			3769.19	3711.33	3756.77	3747.90	3726.76	3772.08	3952.39	3729.01
			3788.11	3730.02	3832.83	3798.92	3776.64	3778.84	3933.11	3157.62
			3798.12	3774.22	3848.11	3781.69	3830.93	2780.01	3900.32	3829.94
	O-H		3811.22	3785.44	3850.82	3789.90	344.93	3801.22	3894.23	3866.58
Alcohol	(medium)	3300-3900	3834.86	3793.95	3862.11	3848.09	3250.68	3824.82	3892.00	3888.88
			3860.79	3803.09	3880.08	3856.12	3245.60	3867.22	3880.86	3892.22
			3872.36	3891.28	3971.53	3867.91	3978.42	3916.72	3861.22	3909.00
			3966.11	3900.63		3889.11		3916.72	3833.79	3920.26
			3919.61	3914.94		3898.00		3949.5	3803.00	3934.07
			3973.61	3931.62		3959.01		3962.1	3790.62	3965.89
			3989.03	3950.46		3966.86		3978.1	3757.63	
				3960.89				3987.82	3740.22	
								3994.52	3729.66	
								3792.611		
	O-H	3200-3550	3352.64	3245.61	3344.93	3352.66	3249.47	3344.87	3354.89	3352.99
	(strong)		3294.79	3308.22	3248.55	3344.56	3344.95	3250.68	3282.72	3251.41
			3249.47	3343.96		3250.63		3245.60	33352.91	
						3244.11				
Aldehyde	C=O	1720-1740	1730.08	1740.44	1736.51	1736.58	1736.58	1736.38	1737.55	1737.55
Carboxylic	O-H									
Acids, Alkane,		2500-3300	2768.66	2763.49	2865.88	2897.52	2776.36	2865.74	2845.98	2867.63
thiol	C-H	2850-3000	2751.72	2749.99	2776.99	2867.36	2768.66	2775.00	2841.42	2798.21
			2734.46	2721.60	2764.40	2753.85	2751.72	2769.37	2719.73	2716.25
					2749.24		2734.87		2846.94	
					2736.49				2766.30	
Anhydrides	C=O	1750;1820	-	-	-	1772.26	-	1775.99	-	1778.82
Isocyanates,										
	-N=C=O		1989.9	1961.93	1888.96	2287.16	1989.9	1895.60	2297.77	188.07
Isothiocyanates,	-N=C=S		1926.54	1990.86	1976.63	2263.66	1900.20	1976.98	2274.00	1927.00
Diimides, Azides,	-N=C=N	1900-2270	1986.43	1900.00	1921.99	2184.77	1925.53	1963.73	2261.42	1900.12
Ketenes, Cyanide	-N3		1968.96	1906.33	1894.54	2151.13	1963.18	1208.23	250.62	1905.91
	C=C=O		1981.22	1912.11	1953.77	2151.15	1972.22	1217.51	2236.11	1957.01
	CN		2003.68	1939.07	2100.91	2163.56	2003.68	1245.94	2211.88	2000.79

Table 1. *Continued ...*

Class	Group	Wavenumber (cm^{-1})	CI 850FT (cm^{-1})	CI 8505 DAS(cm^{-1})	YTP 1FT (cm^{-1})	YTP 15 DAS (cm^{-1})	H740/92 FT (cm^{-1})	H740/925 DAS(cm^{-1})	H226FT (cm^{-1})	H2265 DAS (cm^{-1})
			20271.17	1972.82	2109.22	1860.01	2005.22	1942.96	2205.00	2101.98
			2097.21	2001.25	2182.09	1630.23	2038.21	1200.45	2192.12	2208.33
			2133.24	2028.75	2189.55	1516.74	2066.18	1211.63	2679.88	2146.72
			2165.67	2064.42	1928.27	1382.71	2068.06	1276.96	2158.28	2189.45
			2188.06	2088.57	2100.68	1277.61	2116.84	1952.60	1890.88	2198.43
			2176.82	2106.81	2154.92	1250.61	2136.11	1893.09	1924.61	2278.98
				2095.53	2170.21	2181.19	2172.42	1231.87	1968.96	2238.96
				2126.66	2175.31	2131.05	2180.00	1259.10	2001.75	2284.09
				20145.11	2169.22	2099.23	2208.09	1206.93	2017.78	2212.00
				2153.13	2181.11	2099.26		1200.74	2072.78	2200.48
				2192.67		2068.37		1968.02	2086.00	2100.29
						1988.32		1977.00	2098.44	2106.89
						1211.98		1287.98	2121.28	2270.34
						1208.55		2298.84	2141.88	2281.90
								1287.12	1737.55	2291.00
								1912.34		2287.00
										2297.89
										2295.17
Amines	N-H	3300-3500	3343.96	3352.64	3344.67	3352.64	3344.93	3445.99	3355.78	3352.65
						3344.56				
	C-N	1000-1250	1066.44	1183.11	1100.19	1099.23	1131.05	1130.08	1100.19	1131.77
						1068.37	1211.08	1099.23	1131.05	1167.31
						1099.23	1066.44	1066.44	1219.76	1088.26
						1181.19		1506.13	1133.99	1121.85
						1131.65		1204.65		1208.31
										1289.85
Aromatic	aromatic	1250± 50	1271.82	1277.61	1277.61	1271.82	1211.09	1211.08	1219.76	1279.54
			1210.11	1264.11	1250.61	1211.11		1211.08	1278.57	1211.08
				1206.26						
Nitro	N=O	1530±20; 1350± 30	1506.13	1367.88	1365.35	1382.71	1366.74	1365.35	1366.32	1363.26
			1366.66							
			428.12	508.154	532.257	562.48	337.078	538.42	539.97	593.004
Phosphorous			466.669	495.09	503.33	552.78	496.58	529.12	512.008	525.07
and sulfur	S-OR		472.44	489.82	492.88	537.88	452.93	497.94	493.68	511.68

Table 1. *Continued ...*

Class	Group	Wavenumber (cm^{-1})	CI 850FT (cm^{-1})	CI 8505 DAS(cm^{-1})	YTP 1FT (cm^{-1})	YTP 15 DAS (cm^{-1})	H740/92 FT (cm^{-1})	H740/925 DAS(cm^{-1})	H226FT (cm^{-1})	H2265 DAS (cm^{-1})
compounds (Esters)	P-OR		480.22	472.22	482.11	488.22	438.22	431.04	468.53	500.12
			487.01	460.90	468.61	464.24	430.66	406.007	440.65	482.11
	400-900		498.22	422.33	430.048	432.44	424.84	500.39	452.02	464.22
			507.18	404.22		420.11	412.92	492.72	424.26	644.51
				401.21		416.54				415.58
						410.63				
						470.11				
						452.23				
						440.28				

(DAS - Days After Storage)

sava is largely due to cyanide (King and Bradbury, 1995) and high cyanide parenchyma tubers must be processed before consumption to reduce the amount of toxic cyanogens to a safe level. Ivana *et al*. (2008) reported that glucosinolate breakdown products differ from others due to the instability of the initially formed isothiocyanates at neutral or slightly acidic pH resulting in the production of indole-methanols, ascorbic acid conjugates and oligomeric mixtures and also reaction of organic isothiocyanates with dimethyldioxirane in acetone produces isocyanates in good yields during stored tuber. In addition, Miller and Conn (1980) reported that its activity correlates with cyanogenesis, with cyanogenic plants showing higher activities compared to non-cyanogenic plants and cyanide may also be oxidized *via* the enzyme rhodanase and produces thiosulfate and sulfite (Legras *et al.,* 1990; Halkier and Gershenzon, 2006; Oreilly and Turner, 2003). Yuling Qin *et al.* (2017) reported that carbohydrate and other energy metabolism changes during PPD in cassava tuber. Uarrota *et al.* (2014) findings prompted us to perform more detailed analysis, taking into account the data set related to typical fingerprint regions of carbohydrates (1200-900 cm^{-1}), proteins (1680-1540 cm^{-1}), lipids (3000-1700 cm^{-1}) and nitrogen compounds (1900 - 2250 cm^{-1}) to better identify and discriminate the cultivars according to their biochemical discrepancies over the PPD.

Conclusion

This study provides further evidence for the accumulation of functional compounds are more pronounced in cassava cultivars. This study proved the variability existed among cassava genotypes for PPD, although there were no cassava genotypes with complete tolerance or resistance to PPD. CI 850 and YTP 1 had low reaction to PPD. These cassava genotypes can be used as novel donor sources aimed for developing PPD tolerant genotypes.

Acknowledgement

The authors thank the Professor and Head, Tapioca and Castor Research Station, Yethapur, Salem, Tamil Nadu for timely provided the cassava planting materials from cassava germplasm bank for this research work.

Author Contributions

This is the part of Ph.D student's thesis work (first author S. Sowmyapriya) and all the authors participates in the work in a substantive way and contributed equally.

References

Halkier, B.A. and Gershenzon, J. 2006. Biology and biochemistry of glucosinolates. *Annu. Rev. Plant Biol. 57*: 303-333.

Ivana, Redovnikovi, Tatjana Gliveti, Karmela Delongaand Jasna Vorkapi, 2008. Glucosinolates and their potential role in plant. *Period Biol*. 110(4): 297-309.

King, N.L.R. and Bradbury, J.H. 1995. Bitterness of cassava: identification of a new apiosyl glucoside' and other compounds that effect its bitter taste. *J. Sci. Food Agric*. 68: 223- 2230.

Lalaguna, F. and Agudo, M. 1989. Relationship between changes in lipid with aging of cassava roots and senescence parameters. *Phytochem.* 28: 2059–2062.

Legras, J.L., G. Chuzel, A. Arnaud and Galzy, P. 1990. Natural nitriles and their metabolism. *World. J. Microbiol. Biotechnol*. 6: 83-108.

Miller, J. M. and Conn, E.E. 1980. Metabolism of Hydrogen Cyanide by Higher Plants1. *Plant Physiol.* 22: 1199-1202.

Oreilly, C. and Turner, P.D. 2003. The nitrilase family of CN hydrolysing enzymes– a comparative study. *J. Appl. Microbiol.* 95: 1161-1174.

Sanchez, T., Dufour, D., Moreno, J.L., Pizarro, M., Aragon, I.J., Dominguez, M. and Ceballos, 2013. Changes in extended shelf life of cassava roots during storage in ambient conditions. *Postharvest Biol. Technol.* 86: 520–528.

Uarrota, V. G., R. Moresco, B. Coelho, E. D. C. Nunes, L. M. Peruch, E. D. O. Neubert, M. Rocha and Maraschin, M. 2014. Metabolomics combined with chemometric tools (PCA, HCA, PLS-DA and SVM) for screening cassava (*Manihot esculenta* Crantz) roots during postharvest physiological deterioration. *Food Chem.* 161: 67-78.

Wheatley, C. and Schwabe, W. 1985. Scopoletin involvement in postharvest deterioration of cassava roots (*Manihot esculenta* Crantz). *J. of Exp. Bot*. 36: 783- 791.

Yuling Qin, Djabou, A.S.M., An, F., Li, K., Li, Z. and Yang, 2017. Proteomic analysis of injured storage roots in cassava (*Manihot esculenta* Crantz) under postharvest physiological deterioration. *PLoS One.* 12(3): 174-238.