International Journal of Advances in Engineering and Management (IJAEM)
Volume 7, Issue 04 April 2025, pp: 1200-1205 www.ijaem.net ISSN: 2395-5252

Assessing the Influence of Soot on the Nutritional and Phytochemical Profiles of Plant Species in Asari-Toru, Rivers State, Nigeria

[1]John, Godson Nnamdi, [2]Kpaduwa,Samuel[3]Akpode, Jacob Oloche

[1,2]Department of Biochemistry/Chemistry Technology, School of Science Laboratory Technology, University ofPort Harcourt.
[3]Departmentof Pure and Applied Chemistry, Faculty of Science, Benue State University Makurdi.

Date of Submission: 20-04-2025 Date of Acceptance: 30-04-2025

ABSTRACT
This study was designed to investigate the effects of black soot on the Nutritional and phytochemical properties of plants exposed to it, following the fear that black soot may have direct and indirect effects on vegetation when airborne or buried in the soil. To this end, samples of the plants (cassava and melon) cultivated under the black soot prevalent condition and samples of a control that is cultivated in an environment not exposed to black soot, were analyzed to assess their proximate and phytochemical contents. The results of the proximate analyses that was conducted on the cassava and melon samples cultivated in black soot contaminated soil and the control (cassava and melon) cultivated in black soot free soil reveal that: the effects of black soot is on the proximate composition increased the moisture content (3.98/15.35 - 6.73/24.35%), crude protein (2.74/3.73 - 3.13/4.65%), and fats and oil (8.68/4.89 - 12.15/14.93%) compositions and decreased the ash content (0.41/0.27 - 1.15/0.56%), crude fibre (0.05/0.43 - 0.08/0.57%), and carbohydrate (26.38/9.09 - 30.05/14.00%) compositions of the crops (cassava/melon respectively). Likewise, the effects of the black soot on the phytochemical content of the crops increased the flavonoids(122.21/70.65 - 201.20/106.82 mg/100g), phenolics(92.92/50.46 - 120.00/68.43 mg/100g) and alkaloids (13.15/44.53 - 21.18/71.80 mg/100g); and the decreased the saponins (3.40/7.49 - 2.55/5.45 mg/100g), terpenoids(3.37/4.03 - 1.24/2.05 mg/100g), tanins(3.21/6.01 - 2.90/4.51 mg/100g) and stilbenes(199.10/279.02 - 143.01/205.52 mg/100g) contents of the crop pair. Hence, black soot had both negative and positive effects on the Nutritional and phytochemical contents of the plants.

Keywords: Nutritional,Phytochemical, Plants, Soot and Species

I. INTRODUCTION

Black soot which is sometimes simply referred to as soot is an airborne particulate matter formed as one of the by-products of the incomplete combustion of fossil fuels, biofuel or biomass (Anda&Illes 2012). The black soot so formed as a by-product of incomplete combustion is a complex mixture that is mainly composed of black carbon (BC) and organic carbon (OC) (Taha et al., 2007; Mondal, et al. 2014); although, its composition vary based on the combustible. Also, as a particulate matter, black soot is sometimes called lampblack or carbon black. Because when settled, it is a black powder that has an aerodynamic diameter range of 0.01-2.5 µm (Brown, et al., 2013) which qualifies it as an aerosol (Schmidt, et al., 2010).

Moreso, black soot as an airborne contaminant in the environment has many different sources, all of which are results of some form of pyrolysis. However, it is not entirely limited to the aforementioned sources alone, black soot is also generated from other anthropogenic activities such as artisanal refining of crude oil, emissions from asphalt factories, indiscriminate burning of mixed

International Journal of Advances in Engineering and Management (IJAEM)
Volume 7, Issue 04 April 2025, pp: 1200-1205 www.ijaem.net ISSN: 2395-5252

waste, burning of tyres as well as vehicular emissions (Rivers State Government, 2019).

The fine particles in soot ($PM_{2.5}$) pose peculiar health challenges. When inhaled, the size of these fine particles enables them to penetrate deep into bronchiolar tissue causing oxidative stress and pulmonary inflammation, and possible deoxyribonucleic acid damage (Niranjan and Thakur, 2017; Valavanidis et al., 2013). Short-term effects of these are irritation of the eyes, nose and throat, cough, chest tightness, wheezing, dyspnea and acute exacerbation of asthma, while long-term effects include arrhythmias and lung cancer among others (EPA, 2017; Niranjan and Thakur, 2017). The aim of this study is to investigate the effects of black soot on the proximate and phytochemical properties of plants exposed to it. According to a publication by Ramanathan(2001) the increasing awareness that black soot is having a measurable effect on atmospheric and land surface warming, primarily through radiative scattering and absorption in the atmosphere and through changes to system albedo at the land surface was pointed out. Agreeing with Mitchell, (1956), who has earlier suggested that both of these effects make black soot a potent driver of climate change from local to global scales (Ramanathan, 2007). Also, after CO_2 which exerts a positive radiative forcing of 1.6, black soot is identified as the second largest contributor to global warming, causing a net positive radiative forcing (surface warming) of 1 to 1.2 Wm–2 (± 0.4 Wm–2) through the following processes (Ramanathan, 2007): absorption and interception of direct sunlight (negative forcing) contributing to surface dimming and reducing evaporation and rainfall globally; absorption of the solar radiation reflected by the earth and clouds (positive radiative forcing); deposition on sea ice and snow; increasing the absorption of sunlight (positive radiative forcing); and evaporation of low clouds aided by black soot caused warming (positive forcing) (Schmidt, et al., 2010). Soot emitted to the atmosphere is dry and wet deposited to surface waters and land. A recent report by Zhan et al. (2012) showed that black soot can make up a significant proportion of the organic carbon in soils, but the amount has been found to differ considerably among soil types (Schmidt, et al., 2010). When soot is absorbed by and stored in the soil, it influences the properties, fertility and water retention capacity (Alexis, et al., 2006) of the soil. Although black soot tends to enrich the soil's carbon content, the process may also have negative effects. As the carbon stored in the soil, which is usually of biomass origin, increases the microbial activity of the soil, it reduces the humus content (Wardle, et al., 2008). A further disadvantage of soot in the soil could be its high adsorption capacity, which may bind heavy metals and pesticides (Cornelissen, et al., 2005). Here, the role of black soot in the sorption of pollutants is significant owing to two complementary processes that bind persistent organic pollutants (POPs) to BC: occlusion inside BC pores during soot formation as well as during surface adsorption during and after soot formation (Mattila&Verta, 2008). During origination as well such transports, BC particles sorbxenobiotic and naturally occurring organic pollutants in soils and sediments, controlling their fate and bioavailability. If these enter the food chain, they have a negative effect on all the links in the chain (Anda&Illes, 2012).Earlier studies have suggested that black soot has direct and indirect influences on vegetation citing its role on atmospheric PM and on the soil nutrient cycle-plant nutrient uptake. Thus, believing that black soot may play a major role in hampering the overall growth of plants (Rai et al. 2010; Grantz et al. 2003). However, in a study conducted in 2012, low rates of soot (3 $gm^{-2}week^{-1}$) was applied with a motorized sprayer on maize showed the effect of soot on certain parameters of maize. Black soot pollution was seen to have no influence on maize growth and development. Although leaf withering after full maturity, however, was delayed by the presence of soot (Anda&Illes, 2012).

II. MATERIALS AND METHODS

Sample collection, identification and preparation

Samples of cassava and fluted pumpkin leaves were collected directly from the farm at Asari-Toru Local government area of Rivers State close to where there is artisanal refining, while the controls were collected from a farm at Abonchia, Eleme and were labelled and bagged accordingly. The samples were taken to the laboratory immediately for analysis.The plant samples were identified by a plant taxonomist in the Plant Science and Biotechnology laboratory at the University of Port Harcourt. The leaves were carefully plucked, washed, chopped and sun dried. Furthermore, the samples were oven-dried, macerated to powder and stored until used.

Methods (sample analyses)

Proximate analysis

The proximate analysis was done according to the procedures below.

Determination of Moisture Content

A glass petri-dish was accurately weighed, after which an approximately 1.0 g of sample was added and re-weighed and the weight was recorded as (W1). This was kept in a vacuum oven for 1hour at the 105 °C. The dish was removed from the oven, cooled and re-weighed and recorded as (W2). This process was repeated until a constant weight was attained. This process was repeated for all the samples and the moisture content was calculated in percentage as follows:

% moisture = ((W1-W2)/weight of sample used) ×100

Determination of Ash Content

1.0 g of sample was accurately weighed in a platinum crucible and recorded as W1, was transferred to muffle furnace at the temperature of 5500° for 8 hours until a white ash was obtained. The platinum crucible was removed and placed in a desiccator to cool and weighed, the value was recorded as W2. Percentage was calculated as:

% ash = ((W1-W2)/weight of sample used) ×100

Determination of Fats and Oil

Cold method of extraction was used to determine fats and oils in the sample. 10g of sample was accurately weighed into round bottom flask then 50ml of n-hexane was added to each of the sample and covered for 24hours for proper extraction of oil after which clean and dried empty beaker were heated to dryness and transferred into a desiccator to cool and weighed and new weights taken. Percentage fats were calculated thus:

% Fats or oil = ((W2 - W1)/ weight of sample used) ×100

Crude Fibre Determination

2.0 g of sample was digested in 200 ml of 1. 25% H_2SO_4, the mixture was boiled for 30 mins and was filtered and washed with hot water to reduce acidity. This was tested with pH paper; the residue was again digested in 200 ml of 1. 25% NaoH. The mixture was heated for 30 mins filtered and washed with hot water and dried in an oven. This was transferred to a platinum crucible and weighed (W1) then heated in a furnace of 550 °C to ash and weigh again (W2). Percentage fibre was calculated as:

% crude fibre=(W1-W2/weight of sample used) ×100

Protein Determination

The protein nitrogen in 0. 5 g of dried sample was converted to ammonium sulphate by digestion with concentrated H_2SO_4 and in presence of Cu_2SO_4 and Na_2SO_4. This was heated and the ammonia involved was steam distilled in 4% boric acid solution, the nitrogen from ammonia was deduced from the titration of the trapped ammonia with 0. 1 N H_2SO_4 with methyl red indicator until a pink colouration was observed indicating the end point of titration. Protein was calculated by multiplying the deduced value of nitrogen by a protein constant 6. 25 mg.

Carbohydrate Determination

The carbohydrate content of the samples was estimated as the difference obtained offer substracting the values of organic protein ash content fat or oil, crude fibre, and moisture content from 100 that is

100 - (protein + ash + crude fiber + moisture content)

Phytochemical analysis

The alkaline precipitation gravimetric method by Harborne, (1973) was used for the determination of alkaloids. Flavonoids and phenolic acids as well as terpenoids were also determined using the method described by Harborne (1973). Tannin content was determined by Folin-denis colorimetric method described by Kirk & Sawyer, (1998). Saponin was determined by double solvent extraction gravimetric method. The phytochemical analysis was done in triplicate.

III. RESULTS AND DISCUSSION

Soot Contaminated crops.		Non- soot Contaminated crops.	
Cassava (Manihotsculenta)	**Pumpkin** (telfairiaoccidentalis)	**cassava** (Manihotsculenta	**Pumpkin** (telfairiaoccidentalis

Moisture content (%)	6.73 ± 0.14	24.35 ± 0.14	3.98 ± 0.02	15.35 ± 0.04
Ash content (%)	0.41 ± 0.02	0.27 ± 0.1	1.15 ± 0.03	0.56 ± 0.01
CrudeProtein (%)	3.13 ± 0.21	4.65 ± 0.07	2.74 ± 0.14	3.73 ± 0.14
Fats/Oil (%)	12.15 ± 0.21	14.93 ± 0.71	8.68 ± 0.11	4.89 ± 0.23
Crude Fibre (%)	0.05 ± 0.077	0.43 ± 0.01	0.08 ± 0.07	0.57 ± 0.01
Carbohydrates(%)	26.38 ± 0.02	9.09 ± 0.01	30.05 ± 0.02	14.00 ± 0.01

Note: Values are means of three replicates ± standard error; CP = crude protein & CF = crude fibre.

Table 1: Proximate composition of plants cultivated in soot contaminated soil and non-soot contaminated soil

Phytochemicals (mg/100g)	**Soot contaminated crops**		**Non-soot contaminated crops**	
	Cassava **(**Manihotesculenta)	**Pumpkin** **(**Telfairiaoccidentalis)	**Cassava** **(**Manihotesculenta)	**Pumpkin** **(**Telfairiaoccidentalis)
Flavonoids (mg/100g)	201.20 ± 1.41	106.82 ± 0.14	122.21 ± 2.12	70.65 ± 0.14
Phenolics(mg/100g)	120.00 ± 1.41	68.43 ± 0.21	92.92 ± 0.71	50.46 ± 0.28
Alkaloids (mg/100g)	21.18 ± 1.06	71.80 ± 0.71	13.15 ± 1.13	44.53 ± 0.71
Saponins (mg/100g)	2.55 ± 0.07	5.45 ± 0.21	3.40 ± 0.17	7.49 ± 0.21
Terpenoids (mg/100g)	1.24 ± 0.14	2.05 ± 0.01	3.37 ± 0.71	4.03 ± 0.01
Tanins (mg/100g)	2.90 ± 0.14	4.51 ± 0.07	3.21 ± 0.21	6.01 ± 0.01
Stilbenes (mg/100g)	143.01 ± 1.41	205.52 ± 1.41	199.10 ± 2.12	279.02 ± 1.41

Note: Values are means of three replicates ± standard error.

Table2: Phytochemicalcomposition of plants cultivated in soot contaminated soil and non-soot contaminated soil

Following investigations on the effect of black soot on the proximate composition and phytochemicals content of plants; the results of the proximate analyses (**Table .1**) that was conducted oncassava and c samples cultivated in black soot contaminated soil and the control (cassava and Pumpkin) cultivated in black soot free soil reveal thus. The crops cultivated in the black soot contaminated soil recorded proximate compositions of cassava/pumpkin to be:6.73/24.35, 0.41/0.27, 3.13/4.65, 12.15/14.93, 0.05/0.43 & 26.38/9.09 % representing values formoisture content, ash content, crude protein, fats and oil, crude fibre and carbohydrate respectively;whereas, the proximate compositions of the control (cassava/Pumpkin) was 3.98/15.35, 1.15/0.56, 2.74/3.73, 8.68/4.89, 0.08/0.57 & 30.05/14.00 %; for moisture content, ash content, crude protein, fats and oil, crude fibre and carbohydrate respectively. The crop pair (cassava/Pumpkin) cultivated in the black soot contaminated soil recorded higher compositions ofmoisture content (6.73/24.35), crude protein (3.13/4.65), and fats and oil (12.15/14.93) percentages than the control;while, the control pair were seen to have higher compositions of ash content (1.15/0.56), crude fibre (0.08/0.57), and carbohydrate (30.05/14.00) that the test crop.

Furthermore, the results of the phytochemicalcontents(**Table 2**) show that flavonoids, phenolics and alkaloids contents of the crop pair cultivated in the black soot contaminated soil were higher (201.20/106.82, 120.00/68.43 and 21.18/71.80 mg/100g respectively) than those of the crop pair cultivated in the black soot free soil(122.21/70.65,92.92/50.46 and 13.15/44.53 mg/100g respectively); conversely, the saponins, terpenoids, tanins and stilbenes contents of the crop pair cultivated in the black soot free soil were higher (3.40/7.49, 3.37/4.03, 3.21/6.01 and 199.10/279.02 mg/100g, respectively) than those of the crop pair cultivated in the black soot contaminated soil (2.55/5.45, 1.24/2.05, 2.90/4.51 and 143.01/205.52 mg/100g, respectively).

Summarily, in considering the effects of black soot on the proximate and phytochemical composition of the crop pair (cassava/Pumpkin) premised on the results obtained from the laboratory analyses, black soot is seen to affect the proximate composition of the plants by increasing the moisture content, crude protein, and fats and oil compositions while decreasingthe ash content, crude fibre, and carbohydrate compositions of the crop pair. Also, the effects of black soot on the phytochemical composition of the is observed in the increase of the flavonoids, phenolics and alkaloids contents of the crop pair and the decrease of the saponins, terpenoids, tanins and stilbenes contents of the crop pair.

IV. CONCLUSION.

In conclusion, the findings show the the effects of black soot on the proximate and phytochemical properties of plants exposed to it, conducted by the quantitative analyses of the proximate and phytochemical compositions of cassava and Pumpkin cultivated in black soot contaminated soil revealed a positive result. Where the effects of black soot is seen on the proximate composition to increase the moisture content, crude protein, and fats and oil compositions and decrease the ash content, crude fibre, and carbohydrate compositions of the crops. Also, the effects of the black soot on the phytochemical content of the crops are observed in the increase of flavonoids, phenolics and alkaloids;and the decrease of saponins, terpenoids, tanins and stilbenes contents of the crop pair. Hence, black soot has both negative and positive effects on the proximate and phytochemical contents of the plants.

REFERENCES

[1]. Alexis, C. M. R.;Chabbi, A.; Chaplot, V.; Rasse, D. P. &Valentin, C. (2006) “Black Carbon Contribution To Soil Organic Matter Composition In Tropical Sloping Land Under Slash And Burn Agriculture,” Geoderma, 130(1-2):

[2]. Anda, A. &Illes, B. (2012). Field Study in Simulation Black Carbon Impacts on Maize. Journal OfEnvironmental Protection3:773–781.

[3]. Brown, J.S., Gordon, T., Price, O. &Asgharian, B. (2013). "Thoracic AndRespirable Particle Definitions For Human Health Risk Assessment". Particle AndFibre Toxicology. 10: 12. Doi:10.1186/1743-8977-10-12. PMC 3640939. PMID 23575443

[4]. Cornelissen, O. Gustafsson, T. D. Bucheli, M. T. O. Jonker, A. A. Koelmans&P. C. M. V. Noort, (2005). “Extensive Sorption of Organic Compounds to Black Carbon, Coal, And KerogenIn Sediments And Soils: Mechanisms AndConsequencesFor Distribution, Bioaccumulation, And Biodegradation,” Environmental Science &Technology, 39(18):.6881-6895.

[5]. Grantz, D.A., Garner, J.H.B., Johnson, D.W. (2003): Ecological Effects of Particulate Matter. – Environment International29: 213-239.

[6]. Harbone, J.B. (1973). Phytochemical Methods.Chapman AndHall.1st Ed. London; 288.

[7]. Harborne, J. B.; Baxter, H.; &Moss, G. P., (1999)."General Introduction".Phytochemical Dictionary A Handbook of Bioactive Compounds From Plants (2nd Ed.). London: Taylor &Francis. P. Vii. ISBN 9780203483756.

[8]. Kirk, R.S. &Sawyer, R. (1998).Pearson’s Composition and Analysis of Foods. 9th Ed. Addison Wesley Longman Ltd., England.

[9]. Mattila, T.J. &Verta, M. (2008). Modeling The Importance of Biota and Black Carbon as Vectors Of PolybrominatedDiphenyl Ethers (Pbdes) In The Baltic Sea Ecosystem. Environmental Science Technology42, 4831-4836.

[10]. Mondal, N. K., Panja, D., Das, C., Dey, U. &Das, K. (2014). Impacts Of Vehicle Exhaust Black Soot On Germination Of Gram Seed (CicerArietinumL.). Communications InPlant Sciences: 4(1-2): 01-09.

[11]. Niranjan R &Thakur AK (2017). The Toxicological Mechanisms of Environmental Soot (Black Carbon) And Carbon Black: Focus on Oxidative Stress and Inflammatory Pathways. Frontiers InImmunology8:763.

[12]. RaiK, Kulshreshtha P, Srivastava K &Mohanty CS. (2010). Leaf Surface Structure Alterations Due to Particulate Pollution In Some Common Plants. The Environment30:18–23.

[13]. Ramanathan, V. (2001). Indian Ocean Experiment: An Integrated Analysis of The Climate Forcing and Effects of The

Great Indo-Asian Haze. Journal OfGeophysical Research106, 28371-28398.

[14]. Ramanathan, V. (2007). Role OfBlack Carbon in Global and Regional Climate Changes; Testimonial to House Committee On Oversight And Government Reform: Washington, DC, USA, 17.

[15]. Ramanathan, V. (2007). Warming Trends in Asia Amplified by Brown Cloud Solar Absorption. Nature448, 575-578.

[16]. Rivers State Government (2019).A Study of Airborne Particulates “Black Soot” In Port Harcourt and Its Environs.Published By the Ministry of Environment, Rivers State.

[17]. Rundel, R. (2001). "Polycyclic Aromatic Hydrocarbons, Phthalates, AndPhenols", In Indoor Air Quality Handbook, John Spengleer, Jonathan M. Samet, John F. Mccarthy (Eds), 34:18-34.

[18]. Schmidt, M.W.I.; Skjemstad, J.O.; Czimczik, C.I.; Glaser, B.; Prentice, K.M.; Gelinas, Y.;Shrestha, G., Traina, S. J., &Swanston, C. W. (2010). Review Black Carbon’s Properties and Role in The Environment: A Comprehensive Review. Sustainability: 2: 294-320;

[19]. Taha, G., Box,G.P., Cohen, D.D &Stelcer, E. (2007): Black Carbon Measurement Using Laser Integrating Plate Method. – Aerosol Science and Technology41(3): 266-276.

[20]. Valavanidis A, Vlachogianni T, Fiotakis K &Loridas S (2013). Pulmonary Oxidative Stress, Inflammation and Cancer: Respirable Particulate Matter, Fibrous Dusts and Ozone AsMajor Causes Of Lung Carcinogenesis Through Reactive Oxygen Species Mechanisms.International Journal of Environmental Research and Public Health: 10(9):3886-3907.

[21]. Wardle, D. A.; Nilsson,M. C. &Zackrisson, O. (2008). “Fire-Derived Charcoal Causes Loss of Forest Humus,” Science, 320,(5876): 629. Doi:10.1126/Science.1154960

[22]. Zhan C, Cao J, Han, Y, Hung S, Tu X, Wang P &AnZhis-Heng. (2012). Spatial Distributions and Sequestrations Of Organic Carbon And Black Carbon In Soils From The Chinese Loess Plateau. Science Total Environment465:255–266.