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The Effect of Black Soot on the Proximate and Phytochemical Properties of Plants in Okrika, Rivers State, Nigeria

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Abstract: The study investigates the effects of black soot on the proximate 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 are 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 cassava and melon samples cultivated in black soot contaminated soil and that of the control revealed that: the effect of black soot on the proximate composition of cassava/melon increased the moisture content from (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 and from control to soot affected plants 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 then 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 respectively of the crop pair. Hence, black soot had both negative and positive effects on the proximate and phytochemical contents of the plants.

Keywords: *Effects; Soot; Plants; Proximate, Phytochemical*

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I. INTRODUCTION

Black soot which is sometimes simply referred to as soot is an airborne particulate matter formed as a by-product of fossil fuels, biofuel or biomass (Anda & Illes, 2012) as a result of incomplete combustion. Black soot so formed as a by-product of incomplete combustion is a complex mixture that is mainly composed of carbon black (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). There are different sources of airborne contaminant in the environment, which could be as a result 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 waste, burning of tyres as well as vehicular emissions (Rivers State Government, 2019). Niranjan and Thakur, 2017; Valavanidis et al. 2013 revealed that the short-term symptoms of these effects 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 the plants exposed to it. Black soot has very high effect (Ramanathan, 2001) on atmospheric and land surface warming, which results primarily from 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

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these effects make black soot a potent driver of climate change from local to global scales (Ramanathan, 2007). Immediately after CO_2 which exerts a positive radiative force of 1.6, black soot is identified as the second largest contributor to global warming, causing a net positive radiative force (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 force) contributing to surface dimming and reducing evaporation and rainfall globally; absorption of the solar radiation reflected by the earth and clouds (positive radiative force); deposition on sea ice and snow; increasing the absorption of sunlight (positive radiative force); and evaporation of low clouds aided by black soot caused warming (positive force) (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). 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).

II. MATERIALS AND METHODS

Samples of cassava and fluted pumpkin leaves were collected directly from the farm at Okrika 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.

The proximate analysis was done according to the procedures below.

- *Determination of Moisture Content*

In this determination, a clean, dry glass petri-dish was initially weighed and the weight was recorded (W1). 1.0 g of sample was added into the accurately weighed glass petri-dish. This was kept in a vacuum oven for 1hour at 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*

1.0g 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*

The use of Cold method of extraction was adopted in the determination fats and oils in the sample. A clean and dried empty beaker was heated to dryness and transferred into a desiccator to cool. After cooling, the flask was weighed and was recorded as the initial weight (W1). 10g of the sample was accurately weighed into round bottom flask and then 50ml of n-hexane was added into it and covered for 24hours for proper extraction of oil, after which, the flask and its content was reweighed and new weights taken (W2). Percentage fats were calculated thus:

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

- *Crude Fibre Determination*

2.0 g of sample was added into a beaker and was digested in 200 ml of 1.25% H_2SO_4. The mixture was boiled for 30 minutes 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% Na0H. The mixture was heated for 30 minutes, 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 reweighed again (W2). Percentage fibre was calculated as:

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

- *Protein Determination*

The protein nitrogen in 0.5g dried sample was converted to NH_4SO_4 by digestion with concentrated H_2SO_4 and in presence of $CuSO_4$ 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. 1N H_2SO_4 with methyl red indicator until a pink coloration was observed indicating the end point of titration. Protein was calculated by multiplying the deduced value of nitrogen by a protein constant of 6.25 mg.

- *Carbohydrate Determination*

The carbohydrate content of the samples was estimated as the difference obtained after subtracting the values of

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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

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 on cassava and pumpkin samples cultivated in black soot contaminated soil and the control (cassava and Pumpkin cultivated in black soot free soil) reveal as follows: That 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 for moisture 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 of moisture content (6.73/24.35), crude protein (3.13/4.65), and fats and oil (12.15/14.93) % respectively 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) % than the test crop.

Furthermore, the results of the phytochemical contents (**Table 2**) shows that flavonoids, phenolics and alkaloids content 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).

Table 1 Proximate Composition of Plants Cultivated in Soot Contaminated Soil and Non-Soot Contaminated Soil

Proximate (mg/100g)	**Soot Contaminated crops.**		**Non- soot Contaminated crops.**	
	Cassava (*Manihot sculenta*)	**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 ± 0.10	1.15 ± 0.03	0.56 ± 0.01
% Crude Protein	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
% Carvbohydrates	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 2 Phytochemical 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.

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IV. CONCLUSION

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 both the proximate composition and phytochemical contents of the plants. The effects of black soot is seen on the proximate composition to increase the moisture content, crude protein, fats and oil compositions and decrease in 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 a decrease in 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.

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