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Effect of Wood Ash-Amended Soil on Some Nutritional and Non-Nutritional Constituents of *Telfairia occidentalis*

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Effect of wood ash (WA)-amended soil on some nutritional and non-nutritional constituents of *Telfairia occidentalis* (pumpkin) was evaluated. WA obtained from *Dialiumguineense*(velvet tamarind) tree was used to amend the soil samples. Pumpkin seeds were planted on the soils after allowing for soil mineralization. Results obtained after the pumpkin plants were harvested and processed for analysis showed that cyanogenic glycosides and tannins increased against the control. Moisture and crude fats reduced against the control while carbohydrate increased when compared to the control. Pumpkin grown on WA amended soil samples had reduced vitamin A but increased vitamins C and D. Potassium and calcium minerals increased in pumpkin grown on WA amended soil samples. These observations could be related to the ability of WA to stimulate mineralization which may have influenced some non-nutritional composition such as

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phytochemicals and nutritional compositions such as proximate contents and minerals. In conclusion, WA amended soil had effect on some nutritional and non-nutritional constituents of *Telfairia occidentalis* (pumpkin).

Keywords: Amended soil; nutritional; non-nutritional constituents; pumpkin; wood ash.

1. INTRODUCTION

Wood ash (WA) has been at the center stage of soil fertility in recent years [1-2]. It has been engaged in agricultural practices and positive results have followed its usage with regards to its input to the soil [3]. It is a residue of powdery remains from the burning or combustion of wood [4]. It is among the materials used to maintain the soil quality through replenishment of lost nutrients of the soil [1,5]. The combustion of the wood to ash is made possible through the use of wood stove, fireplaces, bonfire, or industrial plant [6]. The WA has the potential to serve as soil stabilizer, conditioner, and contains desirable elements needed in the production of both food and forage crops [7-8]. Factors such as the nature of the combustion of the wood, the species of the tree that produced the wood, and the processing of the wood are among the key determinates of the chemistry of the ash produced during the combustion of the wood [3,5]. According to Füzesi et al. [9], WA is a non-hazardous waste of non-agricultural origin.

Supplements added to the soil during cultivation are aimed at improving the fertility of the soil for crops and soil sustainability [6,10-11]. A fertile soil is described as one with readily made plant foods. These readily made foods for plants in the soil encourage the proper growth of plants and facilitate the proper development of both nutritional and non-nutritional constituents in plants [12]. These nutritional constituents of plants such as the minerals and other organic nutrients constitute what is established as essential human foods from plants. Essential human foods from plants constitute mostly organic nutrients such as proteins, carbohydrates, lipids, vitamins, and mineral elements [13]. These are required by humans as essentially classes of foods [14]. Plants have also been associated with phytochemicals, which form basically the non-nutritional organics that protect them [15]. They possess the ability of being physiologically active and are bioactive in nature. Terpenoids, saponins, alkaloids, carotenoids, phytosterols, essential oils, organic acids and protease inhibitors are among the phytochemicals that are relevant to plants which are very essential to humans and industries [15].

Existing studies involving WA in relation to agricultural practices have not really looked at how it can affect the constituents of plants grown on soil sample supplemented with WA. Since WA has been established as an agent that can enhance soil fertility and sustainability, it would be interesting to evaluate the nutritionaland non-nutritional constituents of plant growing on WA-supplemented soil. These would provide an insight on how WA relatively influences such constituents with regards to plants when it is used. The present study evaluated the nutritional and non-nutritional constituents of pumpkin plant grown on WA amended soil.

2. MATERIALS AND METHODS

2.1 Procurement of WA and Soil Samples

The WA used in this study was sourced from Ogbo-osisi in Owerri, Imo State, Nigeria. It was made from combusting the wood of *Dialiumguineense* (velvet tamarind) tree in an industrial oven at a very high temperature (350 ºC) till a complete combustion was achieved. The remains after the combustion were regarded as the WA of the velvet tamarind tree. Velvet tamarind tree is known as “Ncheleku”, “Awin”, and “Tsamiyarkurm” by the Igbos, Yorubas, and Hausas tribes of Nigeria respectively. The soil sample used in the present study was procured from Imo State University School farm.

2.2 Soil Preparation and Treatment with WA

Five (5 kg) kilogramme of dried soil samples was procured from the school farm of Imo State University Owerri, and sieved. The soil was collected from the surface to a depth of 0.15 cm into the soil. The collected soil was placed into a plastic container and was prepared by sieving and removing all the unwanted materials. It was then distributed equally into the three plastic perforated buckets. Two of the buckets were treated with WA at the concentrations of 5% for one bucket of the soil and 10% for the other bucket of the soil. One of the buckets served as the control and was not treated. The whole set was allowed to stay for two weeks to allow for the proper mineralization of the soil.

2.3 Plant of Seeds

Pumpkin seeds (*Telfairia occidentalis*) were collected from Agricultural Development Program (ADP) office in Owerri, Imo State. After the preparation of the soil, the seeds were planted on the soil samples. Three seeds were planted per bucket but the seeds were later reduced to two seeds per bucket after two weeks of germinations (to avert overcrowding). The plants were watered (1 liter) on daily basisand were properly taken care of. Unwanted plants/weeds were not allowed to grow in any of the buckets till after the harvest of the pumpkin plants.

2.4 Harvesting Grown Pumpkin and Processing of Harvested Pumpkin for Analysis

The leaves of the pumpkin plants were harvested after 90 days from the date of germination. The harvested leaves were processed by sun drying for two weeks before being ground and used for further studies.

2.5 Determinations of Phytochemical, Proximate, Vitamins and Mineral Compositions of Ground Samples

The phytochemical constituents and vitamin analysis of the samples were carried out using the methods of AOAC [16]. Methods as described by AOAC [17] were used for proximate composition analysis. Minerals such as sodium and potassium were determined using flame photometric method whereas the atomic absorption spectrophotometer method was used to determined calcium, magnesium, iron, cadmium and lead.

3. RESULTS AND DISCUSSION

Phytochemicals are known for their protective action in plants and animals; humans inclusive [18]. It has been reported that some of the nutrients plant need are in WA [2]. The phytochemical constituents of the pumpkin plants (Table 2) show that cardiac glycosides ranged from 0.70±0.14 to 4.39±0.14%. Pumpkin plants grown on soil with 5% WA had the highest constituent of cardiac glycosides of 4.39±0.14%, which significantly ($p<0.05$) increased when compared to the control. Cardiac glycoside content of pumpkin grown on soil the soil with 10% WA insignificantly ($p>0.05$) reduced when compared to the control. Cyanogenic glycosides ranged from 0.97±0.01to 1.24 ± 0.03% with plant grown on untreated soil sample having the highest content. Pumpkin grown on the soil samples amended with 5% and 10 % WA respectively produced cyanogenic glycoside contents that reduced ($p<0.05$) when compared to the control. Chlorophyll contents of the pumpkin plants grown on wood ash amended soil samples were insignificantly ($p>0.05$) reduced against the control. Carotenoids ranged from 2.31 to 14.83 mg/mL. The pumpkin grown on 5% WA amended soil had the highest carotenoids content while the one grown on 10% WA amended soil had the lowest carotenoid content. Pumpkin grown on 5% WA amended soil had significantly ($p<0.05$) increased carotenoids against the control. Pumpkin grown on the soil treated with 10% WA had significantly ($p<0.05$) reduced carotenoids when compared to the control. Tannins ranged from 7.44±0.01 to 17.20±0.03% with pumpkin grown on 5% WA amended having the lowest content. The pumpkin grown on treated soil samples had significantly ($p<0.05$) reduced tannins against the control. Soil type and soil nutrients are among the factors that can affect the phytochemicals in plants. The WA may have facilitated the processes that favoured the development of cardiac glycosides and carotenoids at 5% soil treatment; and tannins at 10% treatment of the soil.

Table 1. Phytochemical constituents of pumpkin plants

Phytochemical	Control	WA (5%)	WA (10%)
Cardiac glycosides (%)	$0.72±0.14^a$	$4.39±0.14^b$	$0.70±0.28^a$
Cyanogenic glycosides (%)	$1.24±0.03^b$	$0.97±0.01^a$	$1.03±0.01^a$
Chlorophyll (µg/cm^2)	$0.13±0.01^a$	$0.12±0.01^a$	$0.11±0.01^a$
Carotenoids (mg/mL)	$2.94±.01^b$	$14.83±0.03^c$	$2.31±0.03^a$
Tannins (%)	$17.20±0.03^c$	$7.44±0.01^a$	$9.64±0.14^b$

Results are mean ±SD of triplicate determinations. Values with different letters of alphabets along the same row are statistically significant at 5% level. WA=Wood Ash

Table 2. Proximate constituents of pumpkin plants

Parameter (%)	Control	WA (5%)	WA (10%)
Moisture	23.95 ± 0.01^{d}	17.21 ± 0.28^{a}	21.37 ± 0.14^{b}
Crude fat	0.95 ± 0.01^{b}	0.64 ± 0.06^{a}	0.50 ± 0.1^{a}
Crude fibre	0.65 ± 0.07^{a}	0.54 ± 0.14^{a}	1.61 ± 0.14^{b}
Ash content	2.06 ± 0.03^{a}	13.61 ± 0.14^{c}	7.28 ± 0.28^{b}
Crude protein	5.95 ± 0.03^{a}	5.60 ± 0.28^{a}	6.65 ± 0.14^{b}
Carbohydrate	64.48 ± 0.28^{a}	79.99 ± 0.14^{c}	67.17 ± 0.14^{b}

Results are mean ±SD of triplicate determination. Values with different letters of alphabets along the same row are statistically significant at 5% level. WA=Wood ash

Table 3. Vitamins constituents of pumpkin plants

Vitamin	Control	WA (5%)	WA (10%)
A (mg/kg)	48.15 ± 0.00^{c}	2.27 ± 0.28^{a}	8.11 ± 0.14^{b}
B_1 (mg/100g)	0.02 ± 0.00^{a}	0.04 ± 0.00^{b}	0.04 ± 0.01^{b}
B_2 (mg/100g)	0.03 ± 0.00^{a}	0.13 ± 0.00^{b}	0.03 ± 0.01^{a}
B_3 (mg/100g)	0.39 ± 0.02^{a}	0.56 ± 0.21^{a}	0.63 ± 0.04^{a}
B_6 (mg/100g)	0.22 ± 0.03^{a}	0.41 ± 0.01^{b}	0.25 ± 0.04^{a}
B_{12} (mg/kg)	0.75 ± 0.14^{a}	0.75 ± 0.28^{a}	4.18 ± 0.14^{b}
C (mg/kg)	50.13 ± 0.14^{a}	57.47 ± 1.41^{b}	63.76 ± 1.41^{b}
D (mg/kg)	7.74 ± 0.14^{a}	12.27 ± 0.26^{b}	11.57 ± 0.57^{b}
E (mg/kg)	22.37 ± 0.14^{b}	15.51 ± 0.14^{a}	49.82 ± 0.14^{c}

Results are presented mean ± SD of triplicate determinations. Values with different letters of alphabets along the same row are statistically significant at 5% level. WA= Wood ash

Park et al. [19] noted that WA can be used as a fertilizer and for replacing nutrients removed during harvest. The same authors noted that WA substantially add to the base status of the soil to which it is applied and acts as low-N fertilizer that could be compared to the action of N:P:K (1:10:50). Moisture content is known for its effects on shelf-life [20]. Moisture and crude fats reduced significantly ($p<0.05$) in pumpkin grown on soil samples amended with WA when compared to the control. Crude fibre and crude protein reduced insignificantly ($p>0.05$) in pumpkin grown on soil sample amended with 5% WA but increased significantly ($p<0.05$) in pumpkin grown on soil sample amended with 10% WA. The low nitrogen concentration in WA as reported by Johansen et al. [2] was expected to bring about a reduced protein content in pumpkin grown on WA amended soil samples but that was not the case with the present study. The nature of the wood from which the WA of the present study was formed may have contained more nitrogen, which actually resulted in increased nitrogen in the soil and subsequently more proteins in the pumpkin plants. Johansen et al. [2] had similar observation with WA in their study and it was due to the ability of WA to stimulate mineralization of soil organic N. The role of WA in supplying minerals to the soil which is taken in by plants has been noted by different authors [1]. These minerals could be behind the significant ($p<0.05$) increase observed in the ash contents of the pumpkin grown on WA treated soil samples against the control. Ash content is related to mineral constituents of a biological material [20]. The carbohydrate constituents of the pumpkin plants increased significantly ($p<0.05$) in the ones grown on WA treated soil samples when compared to the control.

The vitamin constituents of pumpkin plants as present in Table 3 shows that vitamin A ranged from 2.27±0.28 to 48.15±0.00 mg/kg. Vitamin A of pumpkin planted in the treated soil samples significantly ($p<0.05$) reduced when compared to the control. Vitamin B_1 ranged from 0.02±0.00 to 0.04±0.01mg/kg. Pumpkin planted on the treated soil samples had vitamin B_1 contents that increased significantly ($p<0.05$) when compared to the control. Vitamin B_2 ranged from 0.03±0.00 to 0.13±0.00 mg/100g with pumpkin plant on 5% treated soil sample having the highest vitamin B_2content.Vitamin B_2 in pumpkin grown in the 5% treated soil sample significantly ($p<0.05$) increased against the control while the vitamin B_2 in pumpkin grown on soil sample treated with 10% WA had insignificant ($p>0.05$) increase against the control. Vitamin B_3 ranged from 0.39±0.02 to 0.63±0.04 mg/100g with pumpkin grown on 10% treated soil sample having the vitamin B_3. Pumpkin grown on the treated soil samples had vitamin B_3 that increased significantly ($p<0.05$) against the control. Vitamins B_6 and B_{12} ranged from 0.22±0.03 to 0.41±0.01 mg/100g and 0.75±0.14 to 4.18±0.14mg/kg respectively. Pumpkin grown on5% treated soil sample had significantly ($p<0.05$) increased vitamin B_6 but vitamin B_6 insignificantly ($p>0.05$) increased in pumpkin grown on 10% WA treated soil sample. Vitamin C ranged from 50.13±0.14 to 63.76±1.41 mg/kg. Pumpkin from the treated soil samples had significantly ($p<0.05$) increased vitamin C contents against the control. Vitamin ranged from 7.74±0.14 to 12.27±0.26 mg/kg with pumpkin grown on soil sample amended with 5% WA with the highest vitamin D content. Pumpkins grown on the treated soil samples had increased vitamin D contents that significantly ($p<0.05$) increased against the control. Vitamin D ranged from 15.51±0.14to 49.82±0.14 mg/kg with pumpkin grown on soil sample treated with 10% WA with the highest content of vitamin D. Vitamin D in pumpkin grown on 10% WA amended soil sample significantly ($p<0.05$) increased against the control while pumpkin on soil sample treated with 5% WA had vitamin D content that significantly ($p<0.05$) decreased against the control. The dynamics of the observed effects on vitamins on the pumpkin plants could lie within the constituent of the WA that was used in the treatment of the soil samples.

It has been suggested that WA should be used to replace nutrients removed by harvesting of plants, and to overcome nutrient imbalances and deficiencies in the soil [19]. Ash has been described as a residue of organic materials combustion, which contains inorganic nutrients and trace elements of biomass. Calcium concentrations observed in this study ranged from 5.06 to6.48 ppm. Calcium in pumpkin grown on 5% WA amended soil significantly ($p<0.05$) increased against the control but increased insignificantly ($p>0.05$) in pumpkin grown on 10% WA treated soil sample when compared to the control. Potassium ranged from 4.02 to 7.29 ppm and increased significantly ($p<0.05$) in pumpkin grown on WA treated soil samples against the control. Sodium ranged from 4.92 to4.89 ppm while magnesium ranged from 4.78 to 5.28 ppm. Sodium and magnesium insignificantly ($p>0.05$) increased in pumpkin grown on WA treated soil samples when compared to the control. The WA of the present study could be low in sodium and magnesium and could not influence the soil in terms of their addition to the soil. Iron ranged from 0.29 to 0.43 ppm, and increased ($p<0.05$) significantly in pumpkin grown on 5% WA treated soil sample but increased insignificantly ($p>0.05$) in pumpkin grown on 10% WA amended soil sample. Park et al. [19] noted that ash has low concentrations of heavy metals. Cadmium ranged from 0.01 ppm in pumpkin grown on control soil and 5% WA amended soil to 0.02 ppm in pumpkin grown on 10% WA treated soil. Cadmium in pumpkin grown on WA amended soil did not change when compared to the control. Johansen et al. [2] noted that cadmium is among the toxic heavy metals that WA can contain in high concentration and can increase the cadmium accumulation in plants. Pumpkin grown on soil sample treated with 5% WA had significantly ($p<0.05$) reduced lead against the control while the one grown on 10% WA amended soil insignificantly ($p>0.05$) increased in lead when compared to the control. Invariably, ash is low in lead and could not add lead to the soil for the plant to take up. This observation was in line with the report of Park et al. [19]. It has been noted that a number of micronutrients are found in ash but they vary in their dissolution and availability rate. The WA is very reactive in the soil, alters many soil physicochemical properties, increase soil pH and increase the concentrations of some elements [21]. Alkalinity of the soil pH has been recognized as a factor that facilitates the dissolution of minerals in the soil. This could be behind the increased minerals taken by the pumpkin plants grown on the WA-amended soil samples when compared to the control.

Table 4. Mineral constituents of pumpkin plants

Mineral (ppm)	Control	WA (5%)	WA (10%)
Calcium	$5.06±0.11^a$	$6.48±0.13^b$	$5.39±0.07^a$
Potassium	$4.02±0.14^a$	$6.04±0.17^b$	$7.29±0.08^c$
Sodium	$4.92±0.13^a$	$5.28±0.13^a$	$5.28±0.18^a$
Magnesium	$4.78±0.25^a$	$5.28±0.24^a$	$4.89±0.24^a$
Iron	$0.29±0.01^a$	$0.43±0.06^b$	$0.38±0.03^{ab}$
Cadmium	$0.01±0.00^a$	$0.01±0.00^a$	$0.02±0.00^a$
Lead	$0.05±0.00^b$	$0.02±0.00^a$	$0.05±0.00^b$

Results are presented as mean ± SD of triplicate determinations of triplicate determinations. WA= Wood ash. Values with different letters of alphabets along the same row are statistically significant at 5% level

4. CONCLUSION

In conclusion, pumpkin grown on WA-amended soil samples hadcyanogenic glycosides, and tannins reduced against the control. Moisture and crude fats reduced while carbohydrate increased against the control. Moreso, pumpkin grown on WA-amended soil samples had reduced vitamin A but increased vitamins C and D. Minerals such as potassium and calcium increased in pumpkin grown on WA amended soil samples.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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