RESEARCH ARTICLE

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# Studies on Nutrient and Mineral Contents of Fluted Pumpkin Grown in NPK Solution

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## ABSTRACT

**Studies on nutrient and mineral contents of fluted pumpkin, *Telfairia occidentalis* Hooker fil. leaves grown in different NPK 20-10-10 solutions. The solutions varied in the amount of NPK (20-10-10) and granules (25 g, 50 g, 75 g, 100 g, 125 g and 150 g, respectively) dissolved in water containing micronutrients. The growth media were $M^{25}$NPK, $M^{50}$NPK, $M^{75}$NPK, $M^{100}$NPK, $M^{125}$NPK, $M^{150}$NPK, and Control. Two-week old seedlings of fluted pumpkin raised using River-sand were transferred into the growth media; in four replicates. The nutrient (proximate composition, vitamins, and amino acids) and minerals were determined 5 weeks after planting (WAP) following standard procedures. Among the growth media, fluted pumpkin grown in $M^{125}$NPK medium had the highest energy level (1622.12 KJ/100 g) while the lowest energy content (1437.43 KJ/100g) was recorded at $M^{25}$NPK medium. Fluted pumpkin grown in $M^{25}$NPK medium had the lowest percentage crude fibre content, crude fat, fatty acid when compared with other growth media. The leaves grown in $M^{75}$NPK medium had the highest value for total vitamins (water-soluble and fat-soluble). The percentage ratio of EAA to NEAA for the growth media was Control (42.33:57.67), $M^{25}$NPK (38.88:61.12), $M^{50}$NPK (40.45:59.55), $M^{75}$NPK (42.06:57.94), $M^{100}$NPK (41.04:58.96), $M^{125}$NPK (45.97:54.03) and $M^{150}$NPK (41.54:58.46). The results recorded indicated that the proportion of the minerals varied in the hydroponic solutions. The nutrient contents of fluted pumpkin leaves grown in the NPK 20-10-10 media varied at $P \leq 0.05$. The proportion of mineral elements in fluted pumpkin leaves grown under different concentrations of NPK media at 5 WAP varies in their concentrations.**

**Keywords:** Fluted pumpkin, minerals, NPK solutions, nutrient.

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## I. INTRODUCTION

The World today is faced with food insecurity and weather alteration issues. Food security is a function of the population of the people with a correspondent rate of production of crops to suffice their need for nutrition. According to White *et al.* [1], food security is having adequate, harmless, and nourishing food to satisfy nutritional needs. The human population has remained on the rise with a consequent decrease of arable lands for cultivation of crops. According to Okemwa [2], the global population by 2050 is anticipated to rise to 9 billion with the estimation that 50% of the world's arable lands may become unusable for cultivation. The inability of accessing arable lands for cultivation of edible plants is a cause for concern to most inhabitant of southern Nigeria. The shoreline of most riverine areas of Niger Delta has soil forms that can support mostly the growth of mangrove plants. Soils in Niger Delta are characteristically low in fertility, delicate and regularly very weathered with distinctive low-activity muds and low cation exchange capacity [3]. Fubara-Manuel *et al.* [4], observed that agriculturalists have customarily preserved soil fertility status by bush fallowing in this region. Also, some areas of eastern Nigeria are prone to erosion which makes some parts unusable for farming. In a bit to exploit the limited available land for agricultural purposes, the inorganic fertilizer usage was adopted to attain better plant yield, an approach that has not helped sustainable development in the area. The use of N and P fertilizers is a main supplier to eutrophication process in aquatic bodies across the globe [5], [6]. Hydroponic farming is useful for plant mineral nutrition research [7]. This system was used to assess the performance and viability of producing a non-traditional crop in a given environment [8]. The hydroponics technology has been explored to make crop production in areas which ordinarily are not suitable to traditional farming system due some natural or imposed features like poor soil condition, lack of fresh water and climatic changes. According to Falloro *et al.* [9], increased electrical conductivity in the solution reduces the yield of vegetable crops, although, in many cases it improves their nutritional quality as observed in plants grown in both soil and soilless cultures. Non-circulating system allows an entire crop to be grown with only one stock solution of nutrient medium [10]. The preference of soilless medium to soil medium in several countries' greenhouses are due to soil impurity, uneasiness in pH control, electrical conductivity of soil, reduced nutrient presence in soil, delayed growth and crop ripening, limited crop yield, amongst others [11].

Hence, the study assesses the nutrient and mineral contents of fluted pumpkin grown in NPK solutions.

## II. Materials and Methods

### A. Source of Materials and Planting

The seeds of fluted pumpkin were obtained from a farm in Choba, Port Harcourt, and authenticated by a Taxonomist in the University of Port Harcourt Herbarium. The seeds were planted in white sand from the Choba River Port Harcourt, as a medium for germination. The two-week-old seedlings were transferred into a non-circulating hydroponic nutrient system.

### B. Formulation of Hydroponic Solutions

The method of Kratky [12] was used with modification in nutrient formulation and container used. NPK 20-10-10 granular fertilizer was weighed (25 g, 50 g, 75 g, 100 g, 125 g and 150 g, respectively) and transferred into black plastic bowls with the dimensions: 29 cm width, 41 cm length, and 23 cm depth. The same was dissolved with 20 litres of tap water in the plastic bowls leaving a space for aeration with the addition of 20 ml micronutrients stock solution (0.6 g $H_3BO_3$; 0.4 g $MnCl_2.4H_2O$; 0.05 g $ZnSO_4$; 0.5 g $CuSO_4.5H_2O$; 0.02 g $Na_2MoO_4.2H_2O$) and Epsom salt (9.8 g $MgSO_4$). The Control medium (water) was setup without the addition of NPK, micronutrients and Epsom salt. These formulations were replicated four times and designated as $M^{25}$NPK, $M^{50}$NPK, $M^{75}$NPK, $M^{100}$NPK, $M^{125}$NPK, $M^{150}$NPK and Control. The fluted pumpkin seedlings grown in the different solutions were allowed to stand for five (5) weeks before harvest and analyses. The following bioactive compounds were assessed:

### C. Proximate Analysis

Proximate analysis (moisture, ash, protein, carbohydrate, lipid content and crude fibre) was determined using the standard method of Association of Analytical Chemists [13]. Energy value was determined according to the calculation of methods of Okwu and Ukanwa [14], NIS [15], Osborne and Voogt [16] using the equation.

$$\text{Energy (KJ/100 g)} = 4.186\ \{(\%\ \text{crude protein} \times 4) + (\%\ \text{crude fat} \times 9) + (\%\ \text{carbohydrate} \times 4)\}.$$

$$\text{Total fatty acid} = \text{Crude fat} \times 0.83\ [17]$$

### D. Amino Acids

The amino acids preparation and determination using Waters 616/626 LC (HPLC) were carried out according to the method described by Okonwu *et al*. [18], [19].

### E. Vitamins

The extraction and determination of vitamin A, $B_2$, $B_6$, $B_{12}$, and E were according to the method described by Okonwu *et al.* [18], [19] while **v**itamin C was determined using titrimetric method [20].

### F. Pigment Content

The pigments (Chlorophyll and carotenoid) of fluted pumpkin were extracted using acetone according to the methods described by Kukric *et al*. [21], Chang *et al*. [22], and Duma *et al*. [23].

### G. Mineral Elements

The mineral contents (Mg, Cu, Mn, K, Zn, Ca, Na and Fe) of fluted pumpkin were determined using Atomic Absorption Spectrophotometer (AAS).

### H. Statistical Analyses of Data

The data obtained from the performance of fluted pumpkin in the different growth media were subjected to statistical analyses. The treatment means and standard deviations of the data were calculated on the variables assessed using Microsoft Excel 2013 version. Also, Statistical Analysis System (SAS) version 9.0 was used to carry out the two-way analysis of variance (ANOVA) of the data to ascertain significant difference at $P = 0.05$.

## III. Results

### A. Nutritional Composition of Fluted Pumpkin Leaves Grown in NPK 20-10-10 Solutions

The nutritional composition of fluted pumpkin leaves grown in medium with varying concentrations of NPK at 5 WAP is presented in Table I (a and b). Among the growth media, fluted pumpkin grown in $M^{125}$NPK medium had the highest energy level (1622.12 KJ/100 g) while the lowest energy content (1437.43 KJ/100 g) was recorded at $M^{25}$NPK medium. In the proximate composition of the leaves, high fat content was recorded, ranging from 9.99–19.70%. The highest fat content and total fatty acids of the leaves were recorded at $M^{50}$NPKgrowth medium while the lowest was at $M^{25}$NPK medium. Fluted pumpkin grown in $M^{25}$NPK medium had the lowest percentage crude fibre content, crude fat, fatty acid when compared with other growth media. However, increase in the quantity of NPK did not give rise to a corresponding percentage crude protein in that sequence. The ash contents were appreciably high, ranging from 6.44–12.65% with the $M^{75}$NPK medium having the highest ash content while the percentage moisture contents were the lowest (10.56–17.70% range). The percentage carbohydrate content ranges from 24.17–45.98% with the highest carbohydrate content of the leaves at $M^{125}$NPK medium.

TABLE I A: Nutritional Composition of Fluted Pumpkin Leaves Grown in Different NPK 20-10-10 Growth Media at 5 WAP

| Growth medium | Crude fibre (%) | Moisture content (%) | Ash content (%) | Crude protein (%) | Fat (%) | CHO (%) |
|---|---|---|---|---|---|---|
| Control | 3.61 | 12.97 | 9.46 | 25.13 | 12.95 | 35.9 |
| $M^{25}$NPK | 3.28 | 13.37 | 10.00 | 24.76 | 9.99 | 38.61 |
| $M^{50}$NPK | 3.67 | 12.27 | 9.41 | 25.21 | 19.70 | 29.74 |
| $M^{75}$NPK | 8.14 | 17.70 | 12.65 | 19.95 | 15.25 | 26.32 |
| $M^{100}$NPK | 8.88 | 16.90 | 11.27 | 21.71 | 17.07 | 24.17 |
| $M^{125}$NPK | 4.71 | 10.56 | 6.44 | 17.44 | 14.87 | 45.98 |
| $M^{150}$NPK | 5.95 | 12.67 | 8.24 | 19.33 | 12.55 | 41.27 |
| Mean | 5.463 | 13.777 | 9.639 | 21.933 | 14.626 | 34.570 |
| Std. dev. | 2.275 | 2.576 | 2.005 | 3.160 | 3.183 | 8.090 |
| %CV | 41.651 | 18.696 | 20.807 | 14.406 | 21.761 | 23.403 |

CHO = Carbohydrate; Std. dev. = Standard deviation; CV = Coefficient of variation; WAP = weeks after planting.

TABLE I B: NUTRITIONAL COMPOSITION OF FLUTED PUMPKIN LEAVES GROWN IN DIFFERENT NPK 20-10-10 GROWTH MEDIA AT 5 WAP

| Growth medium | Total fatty acids | Energy (KJ/100 g) |
|---|---|---|
| Control | 10.75 | 1509.76 |
| $M^{25}$NPK | 8.29 | 1437.43 |
| $M^{50}$NPK | 16.35 | 1662.26 |
| $M^{75}$NPK | 12.65 | 1349.27 |
| $M^{100}$NPK | 14.17 | 1411.31 |
| $M^{125}$NPK | 12.34 | 1622.12 |
| $M^{150}$NPK | 10.42 | 1487.50 |
| Mean | 12.139 | 1497.093 |
| Std. dev. | 2.641 | 112.497 |
| %CV | 21.759 | 7.514 |

Std. dev. = Standard deviation; CV = Coefficient of variation; WAP = weeks after planting.

### B. *Vitamins Composition*

The composition of vitamins in fluted pumpkin leaves grown in varying concentrations of NPK at 5 WAP is as shown in Table II (a and b). The water-soluble vitamins (39.20, 49.51, 38.30, 61.98, 61.34, 45.11 and 45.41%) of the leaves were higher than the fat-soluble vitamins (17.49, 20.06, 16.84, 10.10, 7.34, 11.28 and 9.28%) for Control, $M^{25}$NPK, $M^{50}$NPK, $M^{75}$NPK, $M^{100}$NPK, $M^{125}$NPK and $M^{150}$NPK growth media, respectively. Vitamin $B_2$ and$B_3$ of the leaves were the least concentrated vitamins (0.01%) among the vitamins and within each growth medium while the most concentrated vitamins were vitamins $B_9$ and C, respectively. The leaves grown in $M^{75}$NPK medium had the highest value for total vitamins (water-soluble and fat-soluble). The percentage ratios of water-soluble vitamins to fat-soluble vitamins for the growth media were water (69.15:30.85), $M^{25}$NPK (71.17:28.83), $M^{50}$NPK (69.46:30.54), $M^{75}$NPK (85.99:14.01), $M^{100}$NPK (89.31:10.69), $M^{125}$NPK (80.00:20.00) and $M^{150}$NPK (83.03:16.97), in that order. Individual vitamins ($B_1$, $B_2$, $B_3$, $B_6$, $B_9$, $B_{12}$, C, A, E and K) values vary across and within different growth media. The fat-soluble vitamins of the leaves grown in varying concentrations of NPK range from 0.02–19.89% while the water-soluble vitamins range from 0.01–28.51%.

TABLE II A: WATER-SOLUBLE VITAMINS CONTENT (%) OF FLUTED PUMPKIN LEAVES GROWN IN NPK 20-10-10 GROWTH MEDIA AT 5 WAP

| Growth medium | $B_1$ | $B_2$ | $B_3$ | $B_6$ | $B_9$ | $B_{12}$ | C |
|---|---|---|---|---|---|---|---|
| Control | 0.08 | 0.01 | 0.01 | 2.12 | 7.82 | 8.58 | 20.58 |
| $M^{25}$NPK | 0.06 | 0.01 | 0.01 | 6.13 | 7.74 | 10.46 | 25.10 |
| $M^{50}$NPK | 0.07 | 0.01 | 0.01 | 5.01 | 8.18 | 7.36 | 17.66 |
| $M^{75}$NPK | 0.05 | 0.01 | 0.01 | 1.54 | 28.51 | 9.37 | 22.49 |
| $M^{100}$NPK | 0.07 | 0.01 | 0.01 | 2.66 | 27.78 | 9.06 | 21.75 |
| $M^{125}$NPK | 0.08 | 0.01 | 0.01 | 4.39 | 12.55 | 8.26 | 19.81 |
| $M^{150}$NPK | 0.05 | 0.01 | 0.01 | 1.77 | 15.82 | 8.16 | 19.59 |
| Mean | 0.066 | 0.01 | 0.01 | 3.374 | 15.49 | 8.75 | 20.997 |
| Std. dev. | 0.013 | 0.00 | 0.00 | 1.795 | 9.144 | 0.996 | 2.392 |
| %CV | 19.36 | 0.00 | 0.00 | 53.18 | 59.05 | 11.38 | 11.39 |

Std. dev. = Standard deviation; CV = Coefficient of variation; WAP = weeks after planting.

TABLE II B: FAT-SOLUBLE VITAMINS CONTENT (%) OF FLUTED PUMPKIN LEAVES GROWN IN NPK 20-10-10 GROWTH MEDIA AT 5 WAP

| Growth medium | A | E | K |
|---|---|---|---|
| Control | 17.27 | 0.19 | 0.03 |
| $M^{25}$NPK | 19.89 | 0.15 | 0.02 |
| $M^{50}$NPK | 16.63 | 0.18 | 0.03 |
| $M^{75}$NPK | 9.95 | 0.13 | 0.02 |
| $M^{100}$NPK | 7.16 | 0.16 | 0.02 |
| $M^{125}$NPK | 11.06 | 0.19 | 0.03 |
| $M^{150}$NPK | 9.13 | 0.13 | 0.02 |
| Mean | 13.013 | 0.161 | 0.024 |
| Std. dev. | 4.848 | 0.026 | 0.005 |
| %CV | 37.26 | 16.17 | 22.01 |

Std. dev. = Standard deviation; CV = Coefficient of variation; WAP = weeks after planting.

### C. *Amino Acids Content*

A total of twenty amino acids were detected and quantified in the leaves of fluted pumpkin grown in varying NPK solutions (Tables 3a and 3b). These amino acids (AA) were nine (9) essential amino acids (EAA) and eleven (11) non-essential amino acids (NEAA). The total amino acids (TAA) content of the leaves was: 41.327, 45.327, 39.823, 44.595, 45.269, 46.136, and 45.686 for the Control, $M^{25}$NPK, $M^{50}$NPK, $M^{75}$NPK, $M^{100}$NPK, $M^{125}$NPK and $M^{150}$NPK growth media, respectively. The percentage ratio of EAA to NEAA for the growth media was Control (42.33:57.67), $M^{25}$NPK (38.88:61.12), $M^{50}$NPK (40.45:59.55), $M^{75}$NPK (42.06:57.94), $M^{100}$NPK (41.04:58.96), $M^{125}$NPK (45.97:54.03) and $M^{150}$NPK (41.54:58.46). Amongst the AA and growth media, valine content of leaves was the most concentrated with $M^{125}$NPK medium having the highest AA value (6.624) with tryptophan content being the lowest (0.157) at Control growth medium, followed by isoleucine (0.227) at $M^{75}$NPK medium. However, the essential amino acids of the leaves for each of the growth media were lower than non-essential amino acids content when compared. For EAA of the leaves, valine content had the highest AA value amongst other growth media, followed by phenylalamine while tryptophan had the lowest value. The AA values recorded in the leaves varied from one medium to another. The range of AA for EAA and NEAA were 0.157–6.624 and 0.409–5.931, respectively.

### D. *Mineral Composition of Fluted Pumpkin Leaves Grown in NPK 20-10-10 Solutions*

The proportion of mineral elements in fluted pumpkin leaves grown under different concentrations of NPK media at 5 WAP varies in their concentrations (Tables 4a and 4b). The concentrations (%) of N, Ca, Mg and K were low compared to concentrations (ppm) of Na, Mn, Fe, Zn and Cu in all the growth media.

TABLE III A: AMINO ACID CONTENT (%) OF FLUTED PUMPKIN LEAVES GROWN IN DIFFERENT NPK 20-10-10 GROWTH MEDIA AT 5 WAP

| Growth medium | EAA | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Thr | Leu | Iso | Lys | Meth | Phe | Try | Val | Hist |
| Control | 3.555 | 1.260 | 0.667 | 1.387 | 0.692 | 2.500 | 0.157 | 4.648 | 2.626 |
| $M^{25}$NPK | 2.594 | 0.544 | 0.428 | 1.174 | 0.717 | 3.843 | 1.663 | 4.817 | 1.845 |
| $M^{50}$NPK | 2.520 | 1.129 | 0.289 | 1.468 | 0.697 | 2.725 | 0.819 | 4.680 | 1.780 |
| $M^{75}$NPK | 2.912 | 1.390 | 0.227 | 1.151 | 0.805 | 3.739 | 1.214 | 5.407 | 1.911 |
| $M^{100}$NPK | 2.371 | 1.715 | 0.328 | 1.665 | 0.656 | 4.189 | 0.690 | 4.403 | 2.561 |
| $M^{125}$NPK | 3.567 | 1.260 | 0.589 | 0.989 | 0.987 | 4.771 | 0.448 | 6.624 | 1.976 |
| $M^{150}$NPK | 2.789 | 1.129 | 0.714 | 0.627 | 0.771 | 5.439 | 0.677 | 5.180 | 1.650 |
| Mean | 2.901 | 1.204 | 0.463 | 1.209 | 0.761 | 3.887 | 0.810 | 5.108 | 2.050 |
| % CV | 16.68 | 29.35 | 41.90 | 28.23 | 14.69 | 26.94 | 61.35 | 14.67 | 18.82 |

WAP = weeks after planting; EAA = Essential Amino acid; Thr = Threonine; Leu = Leucine; Iso = Isoleucine; Lys = Lysine; Meth = Methionine; Phe = Phenylalamine; Try = Tryptophan; Val = Valine; Hist = Histidine.

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TABLE III B: AMINO ACID CONTENT (%) OF FLUTED PUMPKIN LEAVES GROWN IN DIFFERENT NPK 20-10-10 GROWTH MEDIA AT 5 WAP

| Growth medium | NEAA | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ala | Aspa | Asp | Glua | Tyr | Glu | Gly | Pro | Ser | Arg | Cys |
| Control | 0.718 | 0.646 | 0.778 | 5.045 | 1.413 | 2.851 | 5.222 | 2.877 | 0.674 | 2.812 | 0.799 |
| M25NPK | 0.437 | 1.221 | 0.733 | 4.992 | 2.172 | 2.821 | 4.921 | 2.383 | 3.928 | 2.650 | 1.444 |
| M50NPK | 0.411 | 1.086 | 0.688 | 4.156 | 1.540 | 2.349 | 4.621 | 2.656 | 2.561 | 2.488 | 1.160 |
| M75NPK | 0.262 | 1.328 | 0.438 | 5.133 | 2.113 | 2.901 | 2.944 | 2.740 | 5.230 | 1.585 | 1.165 |
| M100NPK | 0.527 | 0.677 | 0.883 | 4.258 | 2.368 | 2.407 | 5.931 | 2.642 | 2.301 | 3.194 | 1.503 |
| M125NPK | 0.409 | 1.074 | 0.684 | 4.015 | 2.697 | 2.269 | 4.596 | 2.714 | 3.017 | 2.475 | 0.975 |
| M150NPK | 0.450 | 0.983 | 0.753 | 5.205 | 3.074 | 2.942 | 5.058 | 2.563 | 1.520 | 2.724 | 1.438 |
| Mean | 0.459 | 1.002 | 0.708 | 4.686 | 2.197 | 2.649 | 4.756 | 2.654 | 2.747 | 2.561 | 1.212 |
| % CV | 30.27 | 25.74 | 19.30 | 11.04 | 26.95 | 11.04 | 19.28 | 5.810 | 54.94 | 19.283 | 21.86 |

WAP = weeks after planting; NEAA = Non-Essential Amino acid; Alanine = Ala; Aspa = Aspartic acid; Asp = Asparagine; Glua = Glutamic acid; Tyr = Tyrosine; Glu = Glutamine; Gly = Glycine; Pro = Proline; Ser = Serine; Arg = Argine; Cys = Cystine.

Among the growth media, the mineral elements range thus: N (0.50–1.37%), Ca (0.20–0.83%), Mg (0.10–0.51%), K (0.08–0.30%), Na (3.54–22.15 ppm), Mn (19.36–71.27 ppm), Fe (44.15–62.75 ppm), Zn (15.80–79.37 ppm), and Cu (4.89–7.95 ppm). The leaves grown in M$^{100}$NPK medium had the highest mineral elements for N, Ca, Mg, K, Zn and Cu compared to other growth media and the least Mn and Na content at M$^{25}$NPK and M$^{125}$NPK, respectively. The percentage potassium (K) was low and ranged from 0.08–0.30 with the lowest and highest percentage concentrations of K at M$^{25}$NPK and M$^{100}$NPK growth media respectively.

TABLE IV A: MINERAL COMPOSITION OF FLUTED PUMPKIN LEAVES GROWN IN DIFFERENT NPK 20-10-10 GROWTH MEDIA AT 5 WAP

| Growth medium | Mineral (%) | | | |
|---|---|---|---|---|
| | N | Mg | K | Ca |
| Control | 0.55 | 0.10 | 0.09 | 0.22 |
| M25NPK | 0.50 | 0.10 | 0.08 | 0.22 |
| M50NPK | 0.56 | 0.11 | 0.09 | 0.20 |
| M75NPK | 1.25 | 0.45 | 0.25 | 0.75 |
| M100NPK | 1.37 | 0.51 | 0.30 | 0.83 |
| M125NPK | 0.72 | 0.13 | 0.19 | 0.44 |
| M150NPK | 0.91 | 0.16 | 0.22 | 0.38 |
| Mean | 0.837 | 0.223 | 0.174 | 0.434 |
| Std. dev. | 0.353 | 0.178 | 0.088 | 0.260 |
| %CV | 42.13 | 79.75 | 50.77 | 59.90 |

Std. dev. = Standard deviation; CV = Coefficient of variation; WAP = weeks after planting.

TABLE IV B: MINERAL COMPOSITION OF FLUTED PUMPKIN LEAVES GROWN IN DIFFERENT NPK 20-10-10 GROWTH MEDIA AT 5 WAP

| Growth medium | Mineral (ppm) | | | | |
|---|---|---|---|---|---|
| | Na | Mn | Fe | Cu | Zn |
| Control | 7.42 | 19.55 | 51.45 | 6.15 | 16.25 |
| M25NPK | 7.00 | 19.36 | 62.75 | 4.89 | 15.80 |
| M50NPK | 7.27 | 20.44 | 44.15 | 7.27 | 16.25 |
| M75NPK | 22.15 | 71.27 | 56.22 | 5.07 | 77.65 |
| M100NPK | 21.54 | 69.46 | 54.37 | 7.95 | 79.37 |
| M125NPK | 3.54 | 31.36 | 49.53 | 5.33 | 44.86 |
| M150NPK | 5.23 | 39.54 | 48.98 | 7.42 | 41.90 |
| Mean | 10.593 | 38.711 | 52.493 | 6.297 | 41.726 |
| Std. dev. | 7.809 | 22.861 | 5.978 | 1.250 | 27.951 |
| %CV | 73.72 | 59.05 | 11.39 | 19.858 | 66.99 |

Std. dev. = Standard deviation; CV = Coefficient of variation; WAP = weeks after planting.

## IV. DISCUSSION

The energy content (1662.26 KJ/100 g) of *T. occidentalis* was optimized at M$^{50}$NPK medium compared to other NPK growth media and the Control, which ranged from 1349.27–1622.12 KJ/100 g). This probably may have occurred due to the presence of phosphorus and potassium in NPK fertilizer. The protein content of *T. occidentalis* grown in different concentrations of NPK was in conformity with the work of Akwaowo *et al.* [24], who observed and recorded 22.4% protein content of pumpkin leaf at 12 weeks. However, this value was lower when compared to 34.6% protein content of fluted pumpkin bought from an open market as reported by Aletor *et al.* [25]. Several researchers [26]-[28] reported varied crude protein content: 29%, 11% and 20.5 g, respectively. The older leaves (50 weeks) of *T. occidentalis* were higher in percentage fibre, crude protein, ash content and fat content while young leaves had higher moisture and carbohydrate content [24]. They also reported energy composition of 905.292 KJ/100 g. This energy composition was low compared to the results obtained in different growth media. The leaves and edible shoots of fluted pumpkin together contain 85% moisture, while the dry portion of what is usually consumed, contains 11% crude protein, 25% carbohydrate, 3.0% fat, 0.58% phosphorus, 4.32% potassium, 0.56% magnesium, 0.47% calcium and 700ppm iron [27]. Food with proper mixture of *T. occidentalis* has the tendency to increase the weight of animals due to inherent rich mineral content [29]. The leaf has high nutritional, medicinal and industrial values being rich in protein 29%, fat 18%, minerals and vitamins 20% [26]. The vegetable contained 20.5g proteins, 45g fat, 23g carbohydrate, 2.2g fibre and 4.8g total ash [28]. According to Worthington [30], nitrogen from any kind of fertilizer affects the amounts of vitamin C and nitrates as well as the quantity and quality of protein produced by plants. Thus, when a plant is treated with a substantial amount of nitrogen, the protein production is increased, and carbohydrate production will reduce.

The mineral composition of *T. occidentalis* varied across growth media. The highest Fe content of the leaves was recorded at M$^{25}$NPK. *Telfairia occidentalis* leaf contains crucial minerals (such as Fe, K, Na, P, Ca, and Mg), vitamins and antioxidants [31]. Ajibade *et al*. [32] reported that the leaves of fluted pumpkin are rich in Fe, thus used to treat anaemia. Iron is a crucial trace element involved in the synthesis of haemoglobin, proper functioning of the central nervous system and in the oxidation of carbohydrates, proteins, and fats [33]. The maximum safe level of Fe reported by the European Economic Commission is 5 mg/kg. The large amounts of ingested iron can cause excessive levels of iron in the blood and high blood levels of free ferrous iron react with peroxides to produce free radicals, which are highly reactive and can damage DNA, proteins, lipids, and other cellular components [34], Ca (0.0 mg) and phosphorus (0.0 mg) [35]. Hotz and Brown [36] observed that the emphasis in the green revolution on cereals to the detriment of production of other secondary staples, and the increase in use of macronutrient fertilisers are likely to be the primary causes of the present extent of Zn deficiencies in human populations. Zinc therefore has a primary role in our food systems strategy [37]. The proportions of the various minerals vary from one plant to another and with the age of the plant [38]. Also, this observation was in line with the of Idris [39], who reported that the leaves of *T. occidentalis* are good sources of K, Cu, Fe and Mn, moderate sources of Mg and Zn which are essential in human and animal nutrition.

The vitamins content of *T. occidentalis* grown in varying proportion of NPK solutions differed. The highest total vitamin was recorded at $M^{75}$NPK growth media. The water-soluble vitamins content of *T. occidentalis* was higher than the fat-soluble vitamins. The values obtained for vitamin C are more than the daily recommended dietary requirement for adults (30 mg/100g/day) [40]. However, the body system readily releases water-soluble vitamins faster than fat-soluble vitamins. The water-soluble vitamin C obtained from fresh *T. occidentalis* grown in hydroponic solutions were higher compared to the works of others [41,42,43,18,19] on the same plant, who reported that vitamin C content of 62.50 mg/100g, 42.22 mg/100g, 64.33 mg/100g, 17.27% and 3.16%, in that order. The water-soluble vitamins (B complexes and C) were more in *T. occidentalis* than the fat-soluble vitamins (A, E and K). However, fat-soluble vitamins play several roles in the human system. Vitamin A is essential in vision [44], [45], gene transcription [45], [46], dermatology [47], and other roles. According to Kornsteiner [48], plants serve as the sources for vitamin E because animal cells are unable to synthesis vitamin E compound.

The non-essential amino acids content of *T. occidentalis* was higher than the essential amino acids. The highest total amino acids (TAA) of *T. occidentalis* were recorded at $M^{125}$NPK growth media. The TAA content (44.023 g/100 g) of *T.* occidentalis was lower compared with the work of Omoyeni *et al.* [49], who reported TAA content of 72.55 g/100 gcp. The essential amino acids obtained in *T. occidentalis* were below the limit reported by FAO [50] for vegetables. These limits (g/100 g cp) were Threonine (4.00), Leucine (7.00), Isoleucine (4.00), Lysine (5.50), Methionine (3.50), Phenylalanine (6.00), Tryptophan (1.00) and Valine (5.00). The valine and phenylalanine contents were high compared to other EAA. It was earlier reported that glutamic acid and aspartic acid were the most concentrated amino acids in *I. gabonensis, C. maxima, A. viridis, B. alba, A. hybridus, V. amygydalina, T. occidentalis* and *T. triangulare* [49], [51]-[53]. In their separate observations, the values obtained were different even though glutamine and aspartate were the most concentrated amino acids. This observation has shown that the concentration and presence of amino acids vary from one plant to another. The medium of propagation of plant is also a key factor to the concentration of amino acids. According to Cuin and Shabala [54], amino acid concentration of plants increased in salt-stressed environments.

## V. Conclusion

Nutrients are vital to increased growth performance of plants and these nutrients are absorbed by plants in the form of solution. The mineral composition of the growth media enhanced the performance and bioactive components of *T. occidentalis.*

## References

[1] White PJ, Broadley MR, and Gregory PJ. Managing the nutrition of plants and people. *Applied and Environmental Soil Science,* 2012; 1-13.

[2] Okemwa E. Effectiveness of aquaponic and hydroponic gardening to traditional gardening. *International Journal of Scientific Research and Innovative Technology,* 2015; 2(12): 21-52.

[3] Opuwaribo EE, Enwezor WO, Ohiri AC., and Undo EJ. *A review of fertilizers*. Federal Ministry of Agriculture, Water Resources and Rural Development, FPDD, 1990: 53-63.

[4] Fubara-Manuel I, Nwonuala A, and Nkakini S. Effect of poultry manure and irrigation depth on the growth of fluted pumpkin (Hook. F) during the dry season in the Niger Delta region of Nigeria. *Research Journal of Applied Sciences, Engineering and Technology*, 2013; 6(18): 3314-3319.

[5] Conley DJ, Paerl HW, Howarth RW, Boesch DF, Seitzinger SP, Havens KE, Lancelot C, and Likens G. (2009). Controlling eutrophication: nitrogen and phosphorus. *Science,* 2009; 323: 1014-1015.

[6] White PJ, and Hammond JP. The sources of phosphorus in the waters of Great Britain. *Journal of Environmental Quality* 2009; 38: 13-26.

[7] Rodriguez-Delfin A. Advances of hydroponics in Latin America. *Acta horticulturae*, 2012; 947: 23-32.

[8] Pelesco VA, and Bentor Jr. MA. Head Lettuce (*Lactuca sativa* L., Asteraceae) production in a non-circulating hydroponic system under the climatic condition of Biliran, Philippines: A preliminary investigation. *Journal of Society and Technology,* 2013; 3: 1-7.

[9] Falloro C, Rouphael Y, Rea E, Battistelli A. and Colla G. Nutrient solution concentration and growing season affect yield and quality of *Lactuca sativa* L. var. *acephala* in floating raft culture. *Journal of the Science of Food and Agriculture,* 2009; 89(10): 1682-1689.

[10] Kratky BA, Maehira GT, Cupples RJ, and Bernabe CC. *Non-Circulating hydroponic methods for growing tomatoes*. Proceedings of the National Agricultural Plastics Congress, 2005; 32: 31-36.

[11] Butt SJ. *The effects of different growing media on the growth, yield and quality of tomato and lettuce grown under greenhouse conditions*. PhD thesis, Faculty of Tekirdag Agriculture Campus, Trakya University, Turkey. 2001; p. 395.

[12] Kratky BA. A simple hydroponic growing kit for short-term vegetables. University of Hawaii CTAHR HG-42, 2002.

[13] AOAC. *Official methods of analysis*. Association of Official Analytical Chemicals, (17th edition). Arlington, USA, 1990.

[14] Okwu DE, and Ukanwa NS. *Nutritive value and phytochemical contents of fluted pumpkin (Telfairia occidentalis Hook F) vegetable grown with different turkey droppings*. African Crop Science Proceedings, held in Egypt, Al Minya, El-Minia. 2007.

[15] NIS. Nigerian Industrial Standard for White Bread approved by Standard Organisation of Nigeria, 2004.

[16] Osborne DR, and Voogt P. *Calculations of calorific value in the analysis of nutrients in roots*. Academic Press, New York, 1978; pp. 239-240.

[17] Greenfield H, and Southgate DAT. *Food composition data, production, management and use*. FAO Rome, Italy, 2003; pp. 223 – 224.

[18] Okonwu K, Akonye LA, and Mensah SI. Comparative studies on bioactive components of fluted pumpkin, *Telfairia occidentalis* Hook F. grown in three selected solid media. *Journal of Experimental Agriculture International*, 2018a; 20(2): 1-10.

[19] Okonwu K, Akonye LA, and Mensah SI. Nutritional composition of *Telfairia occidentalis* leaf grown in hydroponic and geoponic media. *Journal of Applied Science and Environmental Management,* 2018b; 22(2): 153-159.

[20] Okwu DE. Phytochemicals and vitamin content of indigenous spices of South-eastern Nigeria. *Journal for Sustaining Agricultural Environment*, 2004; 6(1): 30-37.

[21] Kukric ZZ, Topalic LN, Kukavica BM, Matos SB, Pavicic SS, Boroja MM and Savic AV. Characterization of anti-oxidant and microbial activities of nettle leaves (*Urticadioica* L.). *Acta Periodica Technologica,* 2012; 43: 257-272.

[22] Chang SK, Nagendra PK. and Amin I. Carotenoid retention in leaf vegetables based on cooking methods. *International Food Research Journal*, 2013; 20(1): 457-465.

[23] Duma M, Alsina I, Zeipiria S, Lepse L. and Dubova L. Leaf vegetables as source of phytochemicals. *Foodbalt,* 2014; 20: 262-265.

[24] Akwaowo EU, Ndon BA, and Etuk EU. Minerals and anti-nutrients in fluted pumpkin (*Telfairia occidentalis* Hook f.). *Food Chemistry*, 2000; 70: 235-240.

[25] Aletor O, Oshodi AA, and Ipinmoroti K. Chemical composition of common leafy vegetables and functional properties of their leaf protein concentrates. *Food Chemistry,* 2002; 78: 63-68.

[26] Tindall HD. *Commercial vegetable growing*. 1stEdn., Oxford University Press, Oxford, UK, 1968.
[27] Oyolu W. Influence of plant density on seed yield of different cultivars of fluted pumpkin. *Acta Horticulture*, 1980; 111: 209-216.
[28] Badifu GIO, and Ogunsua AO. Chemical composition of kernels from some species of Cucurbitaceae grown in Nigeria. *Plant Food Human Nutrition*, 1991; 41: 35-44.
[29] Emeka EJI, and Obidoa O. Some biochemical, haematological and histological responses to a long-term consumption of *Telfairia occidentalis*-supplemented diet in rats. *Pakistan Journal of Nutrition,* 2009; 8: 1199-1203.
[30] Worthington V. Nutritional quality of organic versus conventional fruits, vegetables and grains. *Journal Alternative and Complementary Medicine*, 2001; 7(2): 161 – 173.
[31] Kayode AAA, and Kayode OT. Some medicinal values of *Telfairia occidentalis*: A Review. *American Journal of Biochemistry and Molecular Biology,* 2011; 1(1): 30-38.
[32] Ajibade SR, Balogun MO, Afolabi OO, and Kupolati MD. Sex differences in the biochemical contents of *Telfairia occidentalis* Hook f. *Journal of Food, Agriculture and Environment*, 2006; 4(1): 155-156.
[33] Adeyeye EI, and Otokiti MKO. Proximate composition and some nutritionally valuable minerals of two varieties of. *Capsicum annum* (Bell and Cherry peppers). *Discovery and Innovations*, 1999; 11, 75-81.
[34] Ding AF, and Pan GX. Contents of heavy metals in soils and Chinese cabbages from some urban vegetable fields around Nanjing and human health risks. *Ecology and Environment,* 2003; 12: 409 – 411.
[35] Alegbejo JO. Production, Marketing, Nutritional Value and Uses of Fluted Pumpkin (*Telfairia occidentalis* Hook. F.) in Africa. *Journal of Biological Science and Bioconservation*, 2012; 4: 20-27.
[36] Hotz C, and Brown KH. International Zinc Nutrition Consultative Group (IZiNCG). Technical Document #1. Assessment of the risk of zinc deficiency in populations and options for its control. *Food Nutrition Bulletin* 25, S91-S203, 2004.
[37] Graham RD, and Welch RM. Plant food micronutrient composition and human nutrition. *Communications in Soil Science and Plant Analysis*, 2000; 31: 1627-1640.
[38] Eseyin OA, Sattar MA, and Rathore HA. A review of the pharmacological and biological activities of the aerial parts of *Telfairia occidentalis* Hook f. (Cucurbitaceae). *Tropical Journal of Pharmaceutical Research*, 2014; 13(10): 1761-1769.
[39] Idris S. Compositional Studies of *Telfairia occidentalis* leaves. *American Journal of Chemistry,* 2011; 1(2): 56-59.
[40] National Research Council. *Recommended Dietary Allowance,* U.S.A Nutritional Review, 1984; 395: 374-395.
[41] Babalola OO, Tugbobo OS, and Daramola AS. Effect of processing on the vitamin C content of seven Nigerian green leafy vegetables. *Advanced Journal of Food Science and Technology*, 2010; 6: 303-305.
[42] Okunade OA, and Adesina K. Preliminary Study on the Nutritional, Anti-Nutritional and Elemental Composition of Bishops Vegetable (*Jatropha tanjorensis*) and Cashew Shoot (*Anarcadium occidentale*) Leaves. *International Journal of Advanced Research in Chemical Science (IJARCS)*, 2014; 1(7): 43-46.
[43] Lawal OO, Essien NC, Essien NM, and Ochalla F. Vitamin C content of some processed green leafy vegetables. *European Journal of Experimental Biology*, 2015; 5(2): 110-112
[44] Mcguire M, and Beerman KA. *Nutritional Science from fundamentals to food*. Thomson Wadsworth Belmont. 2007
[45] Combs GF. *The vitamins, Fundamental aspects in nutrition and health*. 3rd ed. Elsevier Academic Press Burlington. 2008.
[46] Duster G. Retinoic acid synthesis and signalling during organogenesis. *Cell*, 2008; 134(6): 921-930.
[47] Nelson A, Jenkins O, and Merran P. Neutrophil gelatinase associated lipocasin mediates B-cis retinoic acid-induced apotosis of human sebaceous gland cells. *Journal of Clinical Investigation*, 2008; 118(8): 1468-1472.
[48] Kornsteiner M, Karl-Heinz W, and Elmadfa I. Tocopherols and total phenolics in 10 different nut types. *Food Chemistry*, 2006; 98: 381-387.
[49] Omoyeni OA, Olaofe O, and Akinyeye RO. Amino Acid Composition of Ten Commonly Eaten Indigenous Leafy Vegetables of South-West Nigeria. *World Journal of Nutrition and Health*, 2015; 3(1): 16-21.
[50] FAO. *Amino acid content of foods and biological data on proteins.* Food and Agricultural Organization of the United Nations, Rome, Italy 1970; p. 285.
[51] Adeyeye EI, and Kenni AM. The comparative evaluation of amino acids profiles of the dehulled and hull parts of *Irvingia gabonensis* seeds. *Biosciences, Biotechnology Research Asia,* 2011; 8 (2): 529-537.
[52] Adesina AJ, and Adeyeye EI. Amino acid profile of three non-conventional leafy vegetables: *C. maxima, Amaranthus viridis* and *Basella alba* consumed in Ekiti State, Nigeria. *IJAPS*, 2013; 3 (1): 1-10.
[53] Arowora KA, Ezeonu CS, Imo C, and Nkaa CG. Protein levels and amino acids composition in some leaf vegetables sold at Wukari in Taraba State, Nigeria. *International Journal of Biological Sciences and Applications*, 2017; 4(2): 19-24.
[54] Cuin TA, and Shabala S. Amino acids regulate salinity induced potassium efflux in barley root epidermis. *Planta,* 2007; 225: 753-761.