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Full Length Research Paper

Effect of plant maturity on the antioxidant properties, total phenolic and mineral contents of *Sesamum radiatum* leaves

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This study investigated the effect of maturity on the total phenolic content, antioxidant properties and minerals of *Sesamum radiatum* leaves. *S. radiatum* seeds were sown on an unfertilized land and the leaves were harvested on weekly basis from the fourth to the tenth week after planting (WAP) when senenescence has started setting in. The total phenolic content, minerals and antioxidant properties of the plant were determined using standard methods. The results obtained showed that total phenol increased from 7, 200 to 16, 907 mg/100 g) during 4 to 10 WAP, respectively. There was no significant difference in the ferric iron reducing antioxidant power (8.96 to 19.19 mg gallic acid equivalents GAE/g) and the free radical scavenging (1, 1 -diphenyl-2-picrylhydrazyl DPPH; 24.44 to 62%) from 5 WAP to 10, but that of 4 WAP was significantly lower compared with others. Calcium (1.85 to 8.00 mg/100 g), iron (0.042 to 0.068 mg/100 g), magnesium (12.50 mg/100 g to 85.83 mg/100 g) and phosphorus (10.17 mg/100 g to 35.60 mg/100 g) were significantly ($p < 0.05$) affected by the maturity of the plant. The study indicated that as the leaf matures total phenol, calcium, phosphorus and iron contents increased and the optimum values were obtained in leaves harvested at the 7 WAP.

Key words: *Sesamum radiatum,* age of plant, antioxidant properties, total phenol, mineral contents.

INTRODUCTION

Sesamum radiatum belongs to the family Pedaliaceae, It is a leafy vegetable locally called Ekuku gogoro in Yoruba language, beni or gingelly (English), 'ridi' (Hausa) (Gill, 1992) and belonging to the group of indigenous vegetables that grow in small quantity in the rural areas. The plant occurs throughout the tropical Africa mainly as weed, where it is gathered in the wild and used as a potherb (Auwalu et al., 2007). It is one of the many neglected leafy vegetables of the tropics despite its medicinal contribution. It is sometimes cultivated to be used as an ingredient that increases the desirable viscosity of sauces. These sauces are mixed with mashed food prepared from cereals or root crop flours,where it adds to the protein, vitamin and mineral contents of predominantly starchy diets of the people of the areas concerned (Oyenuga et al., 1975; Omidiji, 1978). One of the local names in South-Western Nigeria is Ewe atura which means leaves that bring relaxation and health to the body possibly because they relieve constipation and cure other ailments on ingestion (Odugbemi, 2008). The leaves, seeds and oil serve as food especially in farming communities in Nigeria (Akpan-Iwo et al., 2006). The leaves are also used for treating various stomach ailments.

The decoction of the leaves is used for the treatment of catarrh, eye pains as well as bruises and erupted skins. The decoction roots and leaves have been reported to have anti-viral and antifungal activity (Gill, 1992). S. *radiatum* seeds have been shown to be estrogenic and/or antiestrogenic (Collins et al., 1997).

About 80% of the deaths from chronic diseases occur in low and middle- income countries (Yang et al., 2009). Increased fruit and vegetable consumption has been widely promoted because of the health benefits of micro-

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nutrients as well as the many non-nutrient phyto-chemicals associated with health maintenance and prevention of chronic diseases (Steinmets et al., 1996). Greater fruit and vegetable consumption can help to address the double burden of micronutrient deficiencies and chronic diseases. Furthermore, diets rich in micro-nutrients and antioxidants are strongly recommended to supplement medicinal therapy in fighting human immunodeficiency virus/ acquired immune deficiency syndrome (HIV/AIDS) (Friis et al., 2002). Vegetables such as *S. radiatum* are rich in micronutrient and antioxidant; phytochemicals could improve nutrition and help to alleviate HIV/AIDS (Yang et al., 2009).

Antioxidants are important in prevention of pollution damage of plants, disease prevention in both plants and animals and play a very important role in the body defense system and reactive oxygen species (Ou et al., 2002). These naturally occurring compounds present in fruits and vegetables act by scavenging harmful free radicals, which are also implicated in the most common cancers and other degenerative diseases; including poor brain function (Dillard et al., 2000). Research has shown that consumption of antioxidant rich foods has health benefits such as reduction of occurrence and growth of cancer. This is very important in developing countries like Nigeria where cost of health services are not easily affordable. Optimum utilization of indigenous vegetables will also have significant influence on the income of farmers and traders, especially women, and thereby results in the economic growth of the communities and the nation as a whole. Efforts to encourage the utilization of crops like S. *radiatum* vegetable require information on its phenolic content, antioxidant properties and mineral content and the relationship between its stages of maturity. The present study was thereby aimed at examining the best harvesting time for the leaves of *S. radiatum* for optimal benefit to the consumer.

MATERIALS AND METHODS

Land preparation and planting

The study was carried out at the experimental research field of the National Horticultural Research Institute (NIHORT), Ibadan, Nigeria. Ibadan is located on Latitude 7°30' N and longitude 3°54'E, 168 m above sea level (a.s.l.). Annual temperature ranges from an average minimum of 21°C to a mean maximum of 32°C while mean monthly relative humidity ranges between 61 to 83%. The experiment was conducted between July and October 2010. Land was cleared, ploughed, harrowed and thereafter beds measuring 2 by 2 m were made with alleys of 1 m in between each bed. The experiment was established using a randomized complete block design (RCBD) with three replicates and each replicate was sub-divided into 10 sub plots. The seeds were sown 30 cm inter and intra spacing. Normal agronomic practices were observed on the field.

S. radiatum seeds were obtained from a farmer in Oke-Ogun area of Oyo State. The seeds were cleaned, sorted to remove damaged seeds and sown on an unfertilized land. Three seeds were sown per hole.

Selection, sampling, harvesting and sample preparation

In the experiment, dates of shoot emergence from the seeds were noted and only shoots that emerged within the first week after the first emergence were tagged. This was done to ensure some measure of uniformity in age of sampled plants. Plants were randomly sampled at weekly interval from the fourth week after sowing till the leaves become very narrow and unappealing. Final harvesting was done at tenth week after sowing, when the leaves were narrow and the stem woody. The whole plants were harvested by uprooting only from tagged plants and used for subsequent samplings and evaluation. The whole plants were washed with water, drained and dried at a temperature of 50°C for 16 to 24 h. The leaves of the dried samples were plucked, milled to flour using blender, packaged in polyethylene bag and sealed for further analyses.

Determination of total phenolic content

The method was based on procedures described by Chan et al. (2008). The calibration equation for gallic acid was $y = 0.003x + 0.033$ ($R^2 = 0.987$), where y is the absorbance and x is the concentration of gallic acid in mg/L.

Determination of antioxidant activity

Ferric-reducing antioxidant power (FRAP)

The reducing power of the extract was determined according to the method described by Benzie et al. (1999). FRAP was expressed as mg GAE/g. The calibration equation for gallic acid was $y = 0.0086x + 0.00256$ ($R^2 = 0.9779$)

DPPH radical- scavenging activity

The free radical scavenging activity of the extract was determined by the method described by Braca et al. (2001).

Analysis of mineral contents

Determination of mineral content

Phosphorus, calcium, magnesium and iron contents were determined using AOAC (2000) standard methods.

Statistical analysis

The data were subjected to statistical analysis using statistical analysis system (SAS) Package. Analysis of variance (ANOVA) was used to determine the means. Fisher test was used in determining the least significant difference (LSD) of the mean. Test of significant was done at 5% probability level.

RESULTS AND DISCUSSION

Total phenolic content

The total phenolic content of *S radiatum* leaves significantly ($p < 0.05$) increases with maturity. It

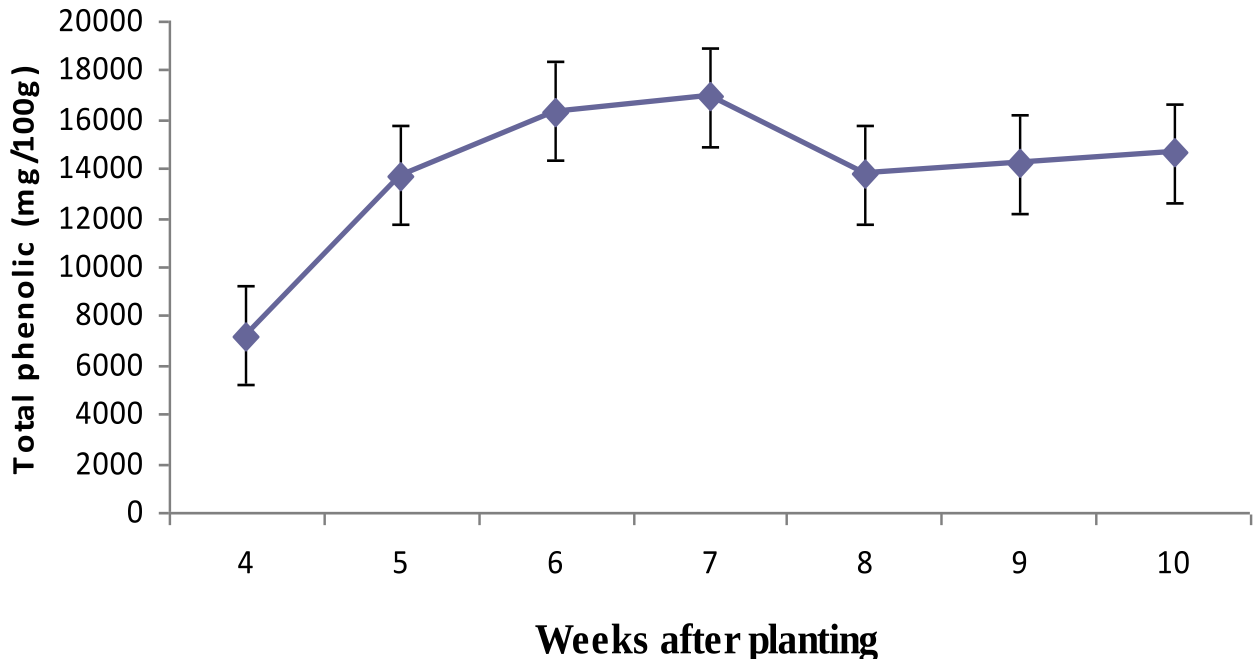


Figure 1. Total phenolic content of Sesamum leaves with increase in age of plant.

increased from 7200 mg/100 g at 4 WAP to 16907 mg/100 g at 10 WAP (Figure 1). Maximum value observed 7 WAP while the minimum value was at 4 WAP. The total phenolic content was significantly lower at 4 WAP compared with other harvesting times. It is obvious that the phenolic content of *S. radiatum* leaves is high at all stages of maturity compared with other fruits and vegetables which vary from 2 to 500 mg/kg (Bravo, 1998). With these values *S. radiatum* could serve as a good source of inhibiting effects of mutagenesis and carcinogenesis in humans when incorporated into diet as supported by Tanaka et al. (1988). The antioxidant activity of phenolic compounds is mainly due to their redox properties, which can play an important role in adsorbing and neutralizing free radicals, quenching singlet and triplet oxygen or decomposing peroxides (Osawa, 1994). These naturally occurring antioxidants present in fruits and vegetables act by scavenging harmful free radicals, which are also implicated in the most common cancers and other degenerative diseases, including poor brain function, etc., (Dillard et al., 2000).

Antioxidant activity

The FRAP of the leaves increased from 4 WAP (8.96 mg GAE/g) to 7 WAP (18.86 mg GAE/g) then had fluctuating trend till 10 WAP (14.63 mg GAE/g). Highest value was obtained at 7 WAP while the lowest value was recorded 4 WAP (Figure 2). No significant difference was observed from 5 to 10 WAP. The frap assay measures the antioxidant effect of any substance in the reaction medium as its reducing ability. The antioxidant activity in *S. radiatum* was found to be higher than other vegetables reported by Ou et al. (2002). Frap examines the interactions among various antioxidants by taking into account their oxidation – reduction potential. As such, the antioxidant effect of *S. radiatum* exponentially increases as a function of the development of its reducing power. Free radical scavenging activity (DPPH assay) of *S. radiatum* is shown in Figure 3. It exhibited a good DPPH radical scavenging activity from 5 WAP (52.47%) to 10 WAP (57.26%) and the highest value was obtained at 9 WAP (62.86%) and a very low DPPH 4 WAP (24.44%) which was significantly lower compared with other harvesting time (Figure 3). The values of free radical scavenging activities are close to the ones reported by Shyamala et al. (2005) which was above 70%. Studies on the fruits and vegetables have shown that the DPPH scavenging activity linearly correlated with the polyphenol content though they contained a notable quantity of vitamin C and carotenes (Robards et al., 1999).

Mineral content

The ranges of the minerals in the leaves that were harvested and analyzed include: calcium 1.85 to 8.0 mg/100 g, iron 0.042 to 0.068 mg/100 g, magnesium 12.50 to 85.83 mg/100 g and Phosphorus with 10.17 to 35.60 mg/100 g (Figure 4a to d) Calcium, magnesium and phosphorus contents increased steadily from 4 WAP

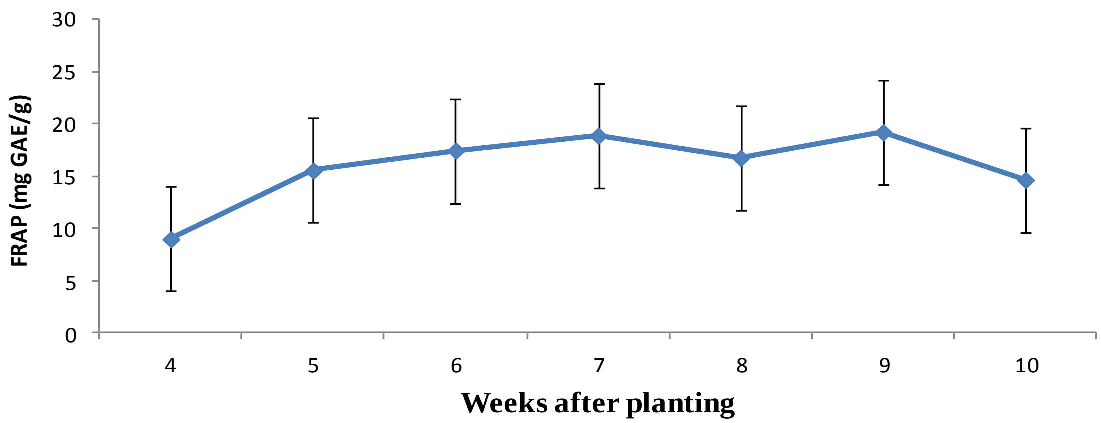


Figure 2. Ferric reducing antioxidant power of leaves with increase in age of plant.

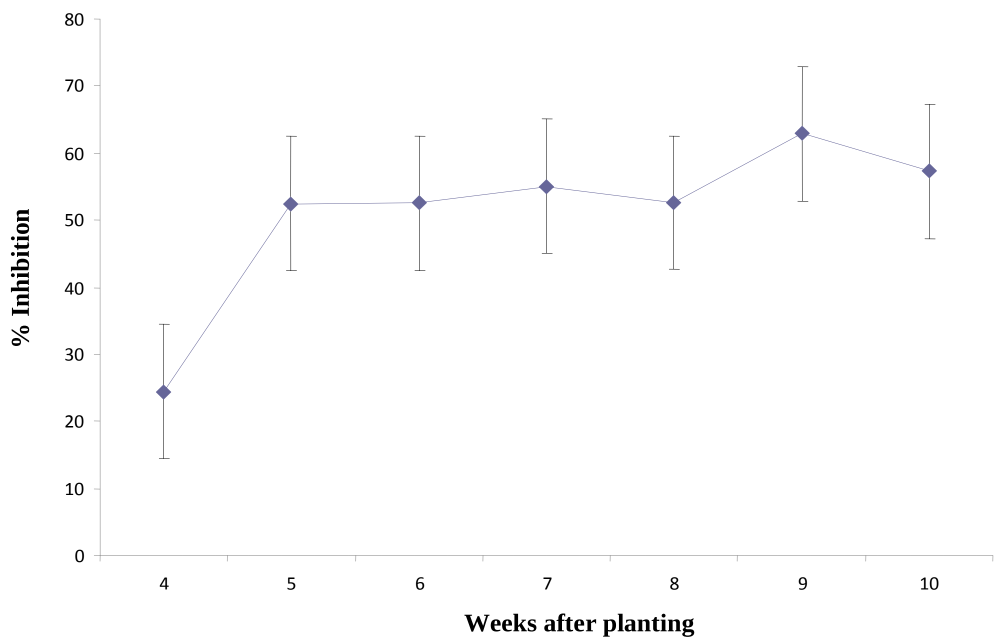
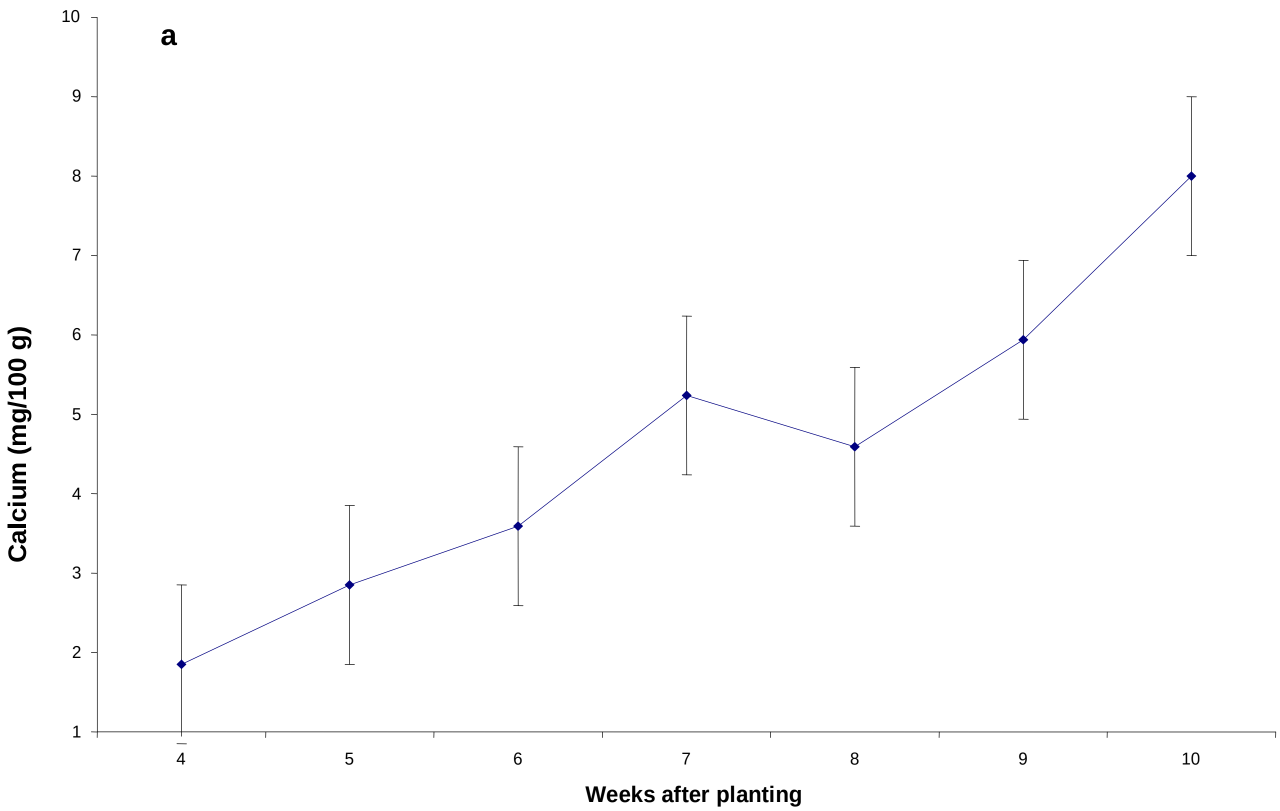


Figure 3. Percentage DPPH inhibition of leaves with increase in age of plant.

till 7 WAP with subsequent decline at the 8 WAP. Values obtained for iron content did not follow any definite trend. Lowest values for all the mineral components were obtained 4 WAP while highest values for magnesium and phosphorus contents were obtained at 7 WAP. Significant variations were observed in calcium, magnesium and phosphorus contents of the leaves with plant maturity while no significant variations was observed in iron content of the leaves with the maturity of the plant. The mineral composition of the vegetable revealed magnesium to be highest when compared to other minerals analyzed, followed by phosphorus. Although the vegetable is very low in iron content, the amount obtained is higher than values reported for some vegetables; *Gnetum Africana*, *Vernonia amygdalina*, *Ocimum grattisimum* and *Amarantus cruentus*, (0.01 to 0.12 mg/100 g) by Mensah et al. (2008).

The highest value of calcium in the leaves (8.00 mg/g) at 10 WAP is relatively high compared to Kale (4.05 mg/100 g) its consumption may be of therapeutic value in hypocalcaemic state like osteoporosis. The value obtained from 4 WAP to the 10 WAP (1.85 mg/100 g to 8.00 mg/100 g) was higher than those reported for Oha (0.20 mg/100 g), 'Nturukpa' (0.03 mg/100 g), Okazi (0.30 mg/100 g), *A. cruentus* (2.05 mg/100 g), Celosia sp. (2.66 mg/100 g) and *V. amygdalina* (2.25 mg/100 g) (Mensah et al., 2008; Ekumankama, 2008). The magnesium content (12.50 t0 85.83 mg/100 g) obtained was found to be higher than that obtained in 'Oha' (P*terocarpus mildbreadii*), (0.25 mg/100 g), 'Nturukpa' (*Pterocarpus*


a
10
9
8
7
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5
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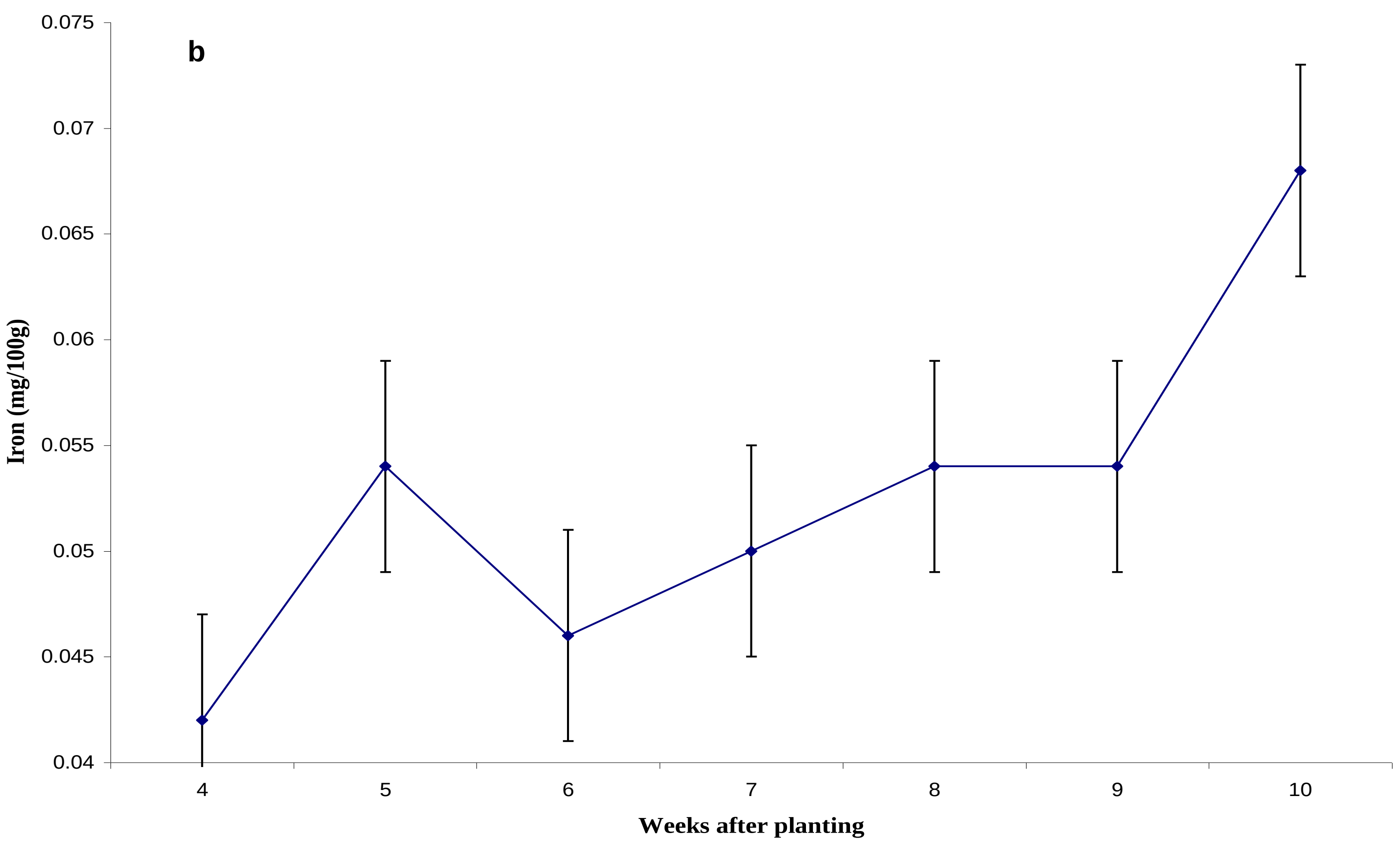
2
1
Calcium (mg/100 g)
4
5
6
7
8
9
10
Weeks after planting


b
0.075
0.07
0.065
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Iron (mg/100g)
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7
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9
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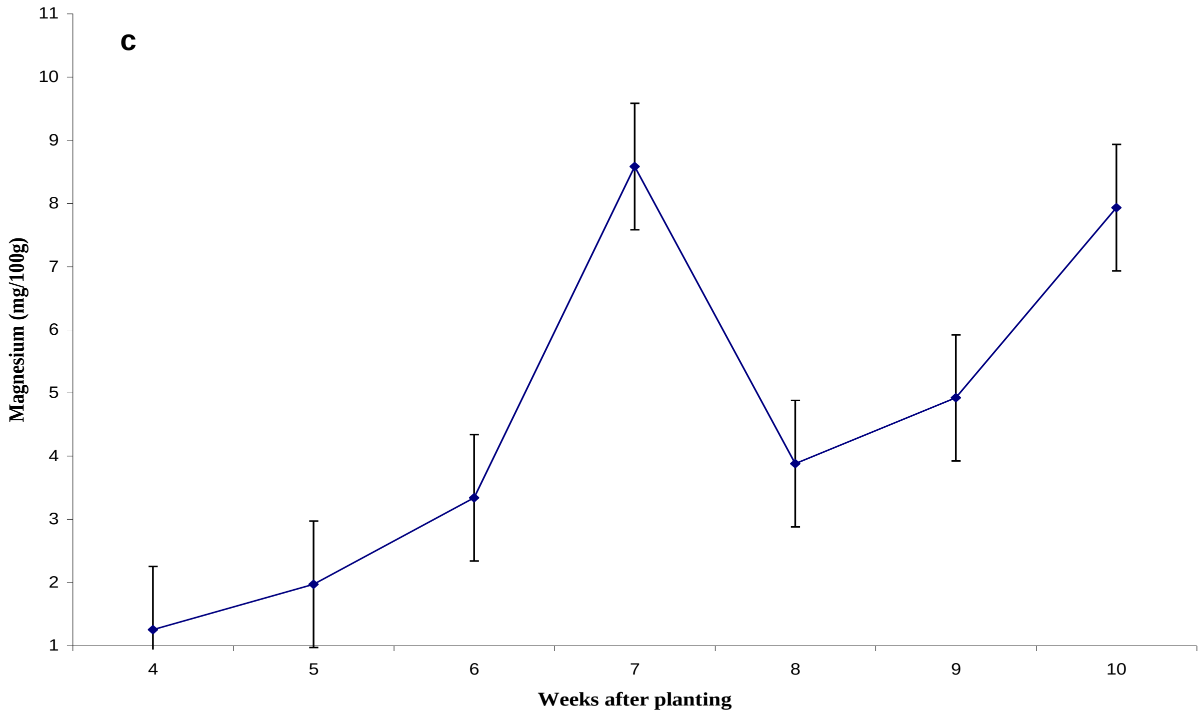
Weeks after planting



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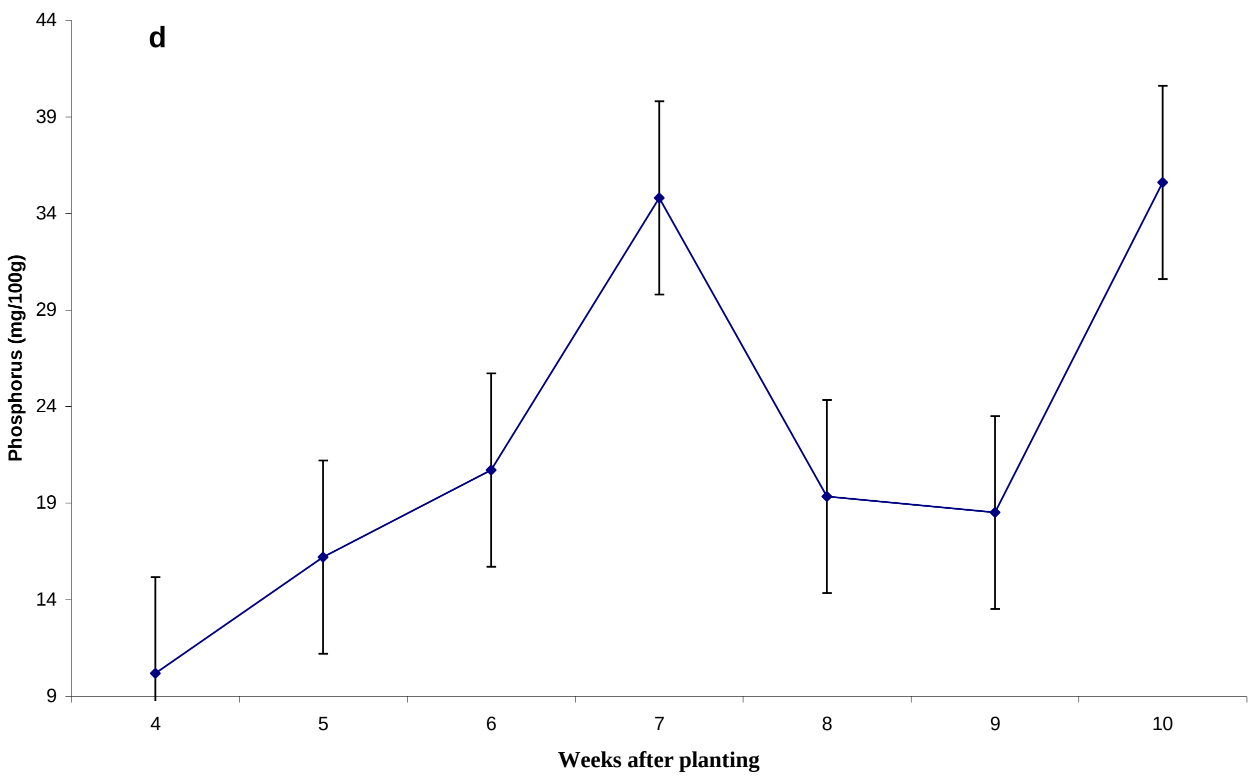

Figure 4. (a) Calcium content of leaves with increase in age of plant; (b) iron content of leaves with increase in age of plant; (c) magnesium content of leaves with increase in age of plant; (d) phosphorus content of leaves with increase in age of plant.

santsliniedes) (0.28 mg/100 g), 'Okazi' (*Gnetum Africana*) (0.21 mg/100 g), *A. cruentus* (2.53 mg/100 g), *Talinum triangulare* (2.22 mg/100 g), Celosia (1.41 mg/100 g) and *Gompholobium latifolium* (1.32 mg/100 g) (Mensah et al., 2008).

Conclusion

The leaves with best attribute in total phenol, calcium, magnesium, ferric reducing antioxidant property and DPPH were obtained from leaves at 7 WAP. Within the limit of the experiment, it was observed that total phenol, calcium, iron, magnesium, phosphorus, ferric reducing antioxidant power and DPPH, were significantly affected by the maturity of the plant. *S. radiatum* is a good source of; total phenols, minerals and antioxidants as such its propagation and utilization should be encouraged. Incorporation of *S. radiatum* leaves in the diet will provide enormous benefits such as provision of vital body constituents, maintenance of fluid balance, formation of hormones and enzymes and; contribution to immune function due to its content.

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