Evaluation of Poultry Manure Application Rates on the Nutrient Composition of *Dioscorea bulbifera* (Aerial yam)

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ABSTRACT

An experiment was conducted to evaluate the effect of various levels of poultry manure application on the nutritional value and functional properties of *Dioscorea bulbifera*. The experiment was a randomised complete block design on a plot size of $8 \text{ m}^2$ with a planting space of $50 \text{ cm} \times 1 \text{ m}$, using 5 levels of poultry manure: 0, 1, 2, 3 and 4 tonnes/ hectare. Standard analytical methods were used to determine the proximate and mineral composition as well as the functional properties of the bulbils. Poultry manure application significantly increased the starch content. The highest starch yield (13.50%) was observed at 4 tonnes/hectare poultry manure application. The dry matter and fat contents were not significantly affected by poultry manure application. Crude fibre, ash and crude protein contents were significantly affected by poultry manure application. Ash content ranged from 3.41 – 4.68% with 4 t/ha level of application having the highest ash content. The crude protein content ranged from 2.48 – 6.28%. The highest crude protein content was observed at 3 t/ha. The total carotenoid content was not significantly affected by poultry manure application. The phosphorus, calcium and magnesium contents were significantly affected by poultry manure application. Water and oil absorption capacity increased with increase in the level of poultry manure while the bulk density was not significantly affected by the level of poultry manure. Application of poultry manure was found to significantly influence the nutrient content and functional properties of *D. bulbifera*.

Keywords: *Dioscorea bulbifera*, poultry manure, proximate composition, functional properties.

Introduction

* Dioscorea bulbifera* L. also known as aerial yam, air potato, bulbil bearing yam, turkey liver yam is an under-utilized yam variety. The edible species of *D. bulbifera* are grown in West Africa, the Carribean Islands, South East Asia, South Pacific and West Indies. The wild forms occur in both Africa and Asia (Abara, 2011). The bulbils are brown in colour, hard with yellow mucilaginous flesh; some varieties may need detoxification by soaking or boiling before they are eaten. *Dioscorea bulbifera* is used as food and is a good source of iron, phosphorous and calcium (Abara et al., 2000). They are usually eaten boiled, roasted and rarely pounded as ‘fufu’. Information is scanty on the nutrient and functional properties of *Dioscorea bulbifera* in Nigeria. Farmers rarely use chemical fertilizer due to scarcity and cost, hence the dependence on cheaper organic sources of nutrients. Falak et al., (2011) reported that NPK fertilizers had significant effect on nutrient composition of potato. Organic manure alone or combined with NPK has been reported to increase crude protein, ash and crude fat content of *Amaranthus* significantly on immediate and residual basis (Makhinde et al., 2010). Most agronomic studies on the effect of organic manure have been centred on the morphological growth and yields of yam without much reference to the effect on the food qualities of the crop grown. Based on

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these facts, this experiment was therefore carried out to study the effect of poultry manure on the chemical composition and functional properties of the bulbils of *D. bulbifera* in the forest zone of south-eastern Nigeria. The objective of this study is to determine the poultry manure rate that gives optimum nutritional and functional properties. Information provided by this research will be useful to product developers, farmers and other researchers.

**Materials and Methods**

*D. bulbifera* was planted in the 2012 cropping season at National Root Crops Research Institute, Umudike farm on a sandy loamy soil. The plot size was 8 m² with a planting space of 50 cm x 1 m. The experiment was a randomized complete block design replicated three times and consisted of five rates of poultry manure; 0, 1, 2, 3 and 4 t/ha. Samples were collected after harvest for laboratory analysis. Starch yield was determined according to the method of Sofa-Kantanka and Osei-Minta (1996). The amount of dried starch obtained from 100 g of the fresh sample was weighed and expressed as a percentage of the fresh sample. The starch yield was calculated as follows:

\[
\text{Starch yield} = 100 \times \left( \frac{\text{WDS}}{\text{WFTR}} \right)
\]

Where:

- WDS = The weight of dried starch
- WFTR = The weight of fresh sample

**Proximate composition**

Moisture content (on fresh weight basis) was determined on fresh sliced samples after oven drying at 105°C for 24 h according the procedure of AOAC (1990). Crude fat was determined by exhaustively extracting samples of flour in a soxhlet apparatus using petroleum ether as solvent. Nitrogen was determined by the Kjeldahl method reported by AOAC (1990) and crude protein content was calculated by multiplying the nitrogen content by a factor of 6.25. Ash content was determined by measurement of residues left after combustion in a furnace at 550°C for 8 h (AOAC, 1990). Ca, K, P and Mg contents were determined using the method of James (1995).

**Determination of bulk density**

The bulk density was determined by the method of Wang and Kinsella (1976). About 5 g of the sample was weighed into 50 ml graduated measuring cylinder. The samples were packed by gently tapping the cylinder on the bench top 10 times from height of 5 cm. The volume of the sample was recorded.

\[
\text{Bulk density (g/ml)} = \frac{\text{Weight of the sample}}{\text{Volume of the sample after tapping}}
\]

**Determination of water and oil absorption capacity**

Water absorption capacity was determined using the method of Sathe *et al.* (1981) with slight modifications. 10 ml of distilled water was added to 1.0 g of the sample in a beaker. The suspension was stirred using a magnetic stirrer for 5 min. The suspension obtained was thereafter centrifuged at 3555 rpm for 30 min and the supernatant measured in a 10 ml graduated cylinder. The density of water was taken as 1.0 g/cm³. Water absorbed was calculated as the difference between the initial volume of water added to the sample and the volume of the supernatant. The same procedure was repeated for oil absorption except that oil was used instead of water.

**Determination of swelling index**

The swelling capacity of the samples was determined using the method of Lin *et al.* (1974), with slight modification. About 1 g of the flour sample was dispersed in 10 ml of cold distilled water in a graduated centrifuge tube. The suspension was left at room temperature for 5 min to absorb water but not to swell. After 5 min the mixture was centrifuged at 2000 rpm for 30 min and the volume of the sediment recorded as initial volume. Another 1 g of the sample was dispersed in a centrifuge tube of known weight and the suspensions heated in boiling water for 30 min. The suspension was
cooled to room temperature under the tap water and then centrifuged at 2000 rpm for 30 min. The volume of the heated sediment was recorded as final volume:

\[
\text{Swelling Index} = \frac{\text{Final volume after heating}}{\text{Initial volume before heating}}
\]

Statistical Analysis
Each experiment was replicated three times. The data were subjected to analysis of variance (ANOVA) using the SAS statistical package version 9.0. Means were separated using Fischer’s LSD at 5% level of probability.

Results and Discussion
Table 1 shows that the nutrient content of \(D. \ bulbifera\) is affected by different levels of poultry manure. The starch content is the main yam quality factor (Otegbayo et al., 2011). The application of poultry manure increased the starch yield significantly \((p \leq 0.05)\). A similar observation was made by Kayode (1985) on \(Dioscorea \ rotundata\) and Oliveira (2002) on \(D. \ Cayenensis\). The highest starch yield (13.50%) was observed at 4 t/ha application of poultry manure. Dry matter contents are associated with the amounts of starch, proteins, fat, fibre and mineral constituents present (Falak et al., 2011). The dry matter content of the bulbils of \(D. \ bulbifera\) ranged from 22.28 – 32.67%. Dry matter content was not significantly affected by the different levels of poultry manure. Poultry manure application of 2 t/ha gave the highest dry matter content. The crude fat content was not significantly affected by poultry manure application. Application of poultry manure tended to increase the crude fibre content of \(D. \ bulbifera\). Fibre provides bulk to the stool which enhances the movement of food through the digestive tract (Abara et al., 2011).

Relative to the control, poultry manure significantly increased the ash content of \(D. \ bulbifera\). A similar observation was made by Ojeniyi and Adejobi (2002) on amaranthus. The increase in ash content with increase in level of poultry manure translates to increase in mineral composition of the tubers. This shows that the application of poultry manure not only supplies micronutrients to the soil, but also leads to increase in micronutrient composition of the harvested crop. The highest ash content was observed at 2 t/ha application of poultry manure. Further increase in application of poultry manure resulted to a decrease in the ash content. The increase in the application of poultry manure may have resulted to high concentration of minerals in the soil which in turn may have caused an outward flow of minerals from the bulbils.

Table 1: Effect of different levels of poultry manure on nutrient composition of \(D. \ bulbifera\)

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Starch (%)</th>
<th>Dry matter (%)</th>
<th>Moisture (%)</th>
<th>Fat (%)</th>
<th>Fibre (%)</th>
<th>Ash (%)</th>
<th>Protein (%)</th>
<th>P (ppm)</th>
<th>Ca (%)</th>
<th>Mg (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>12.49\textsuperscript{a}</td>
<td>29.27\textsuperscript{a}</td>
<td>70.73\textsuperscript{a}</td>
<td>0.37\textsuperscript{a}</td>
<td>2.52\textsuperscript{e}</td>
<td>3.73\textsuperscript{b}</td>
<td>1.35\textsuperscript{d}</td>
<td>5.21\textsuperscript{c}</td>
<td>1.41\textsuperscript{a}</td>
<td>0.25\textsuperscript{a}</td>
</tr>
<tr>
<td>1 t/ha</td>
<td>11.39\textsuperscript{a}</td>
<td>29.91\textsuperscript{a}</td>
<td>70.09\textsuperscript{a}</td>
<td>0.26\textsuperscript{a}</td>
<td>3.42\textsuperscript{c}</td>
<td>3.78\textsuperscript{b}</td>
<td>1.36\textsuperscript{d}</td>
<td>5.42\textsuperscript{b}</td>
<td>0.81\textsuperscript{c}</td>
<td>0.12\textsuperscript{b}</td>
</tr>
<tr>
<td>2 t/ha</td>
<td>11.56\textsuperscript{a}</td>
<td>31.02\textsuperscript{a}</td>
<td>68.98\textsuperscript{a}</td>
<td>0.16\textsuperscript{a}</td>
<td>2.77\textsuperscript{d}</td>
<td>4.68\textsuperscript{a}</td>
<td>1.98\textsuperscript{c}</td>
<td>5.46\textsuperscript{a}</td>
<td>1.42\textsuperscript{a}</td>
<td>0.13\textsuperscript{b}</td>
</tr>
<tr>
<td>3 t/ha</td>
<td>12.11\textsuperscript{a}</td>
<td>31.06\textsuperscript{a}</td>
<td>68.94\textsuperscript{a}</td>
<td>0.14\textsuperscript{a}</td>
<td>5.03\textsuperscript{b}</td>
<td>3.41\textsuperscript{b}</td>
<td>2.82\textsuperscript{b}</td>
<td>5.18\textsuperscript{c}</td>
<td>1.03\textsuperscript{b}</td>
<td>0.23\textsuperscript{a}</td>
</tr>
<tr>
<td>4 t/ha</td>
<td>13.50\textsuperscript{a}</td>
<td>31.67\textsuperscript{a}</td>
<td>68.33\textsuperscript{a}</td>
<td>0.11\textsuperscript{a}</td>
<td>5.16\textsuperscript{a}</td>
<td>1.90\textsuperscript{d}</td>
<td>4.24\textsuperscript{a}</td>
<td>5.47\textsuperscript{a}</td>
<td>1.05\textsuperscript{b}</td>
<td>0.12\textsuperscript{b}</td>
</tr>
</tbody>
</table>

Means with different letters on the same column are significantly different \((p < 0.05)\)
The percentage crude protein of *D. bulbifera* bulbils tended to increase as the rate of poultry manure application increased. The highest crude protein content of 4.24% was observed at 4 t/ha application of poultry manure. This increase in protein may be as a result of absorption of more nitrogen from the soil. Naz *et al.* (2011) reported that addition of organic manure quickens the release of minerals from the soil and helps to make soil nutrients available to plants. This shows that increase in fertilization also increases the content of protein. A similar result was reported by Igyor *et al.* (2004). The water absorption capacity of the *D. bulbifera* samples ranged from 1.75 – 2.05%. A similar result was obtained by Igyor *et al.* (2004). The water absorption capacity (WAC) of *D. bulbifera* tended to increase with increase in the level of poultry manure. 4 t/ha level of poultry manure application gave the highest water absorption capacity. WAC is a function of the protein content of the crop. The increase in protein content with increase in poultry manure application may be the reason for the increase in WAC. WAC is desirable in food systems to improve yield and consistency and give body to the food (Oosundahunsi *et al.*, 2003). Imbibition of water is an important functional trait in foods such as sausages, custards and doughs. Oil absorption capacity which ranged from 1.38% – 2.38% increased with increase in poultry manure application. Oil absorption capacity depends on the ability of protein to absorb and retain oil. Oil absorption capacity is useful in structure interaction in food especially in flavour retention, improvement of palatability and extension of shelf life particularly in bakery or meat products (Adebawale and Lawal, 2004). The gelatinization temperature ranged from 74°C – 85.5°C. The least gelatinization temperature was obtained at 0 t/ha level of application. Application of poultry manure significantly increased the gelation temperature.

It is therefore suggested that *D. bulbifera* that is intended to be used for food products that require low gelation temperature (such as baby formulae) should be grown with low level of poultry manure.

Swelling index reduced with increase in poultry manure level (200.16 – 103.52). Moorthy and Ramanujam (1986) reported that the swelling index of flour granules is an indication of the extent of associative forces within the granule. The extent of swelling in the presence of water depends on the temperature, availability of water, species of starch, extent of starch damage due to thermal and mechanical processes and other carbohydrates and protein such as pectins, hemicelluloses and cellulose etc. (Ezema, 1989). Bulk density was not significantly affected by poultry manure. Bulk density is important in determining the packaging requirement and material handling (Karuna *et al.*, 1996). Bulk density is influenced by particle size; application of poultry manure did not affect the density of *D. bulbifera*.

<table>
<thead>
<tr>
<th>Sample</th>
<th>WAC(%)</th>
<th>OAC(%)</th>
<th>GTT(°C)</th>
<th>SI</th>
<th>BD(g/cm³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 t/ha</td>
<td>1.95ᵇ</td>
<td>1.92ᵇ</td>
<td>74.00ᶜ</td>
<td>200.16ᵃ</td>
<td>0.99ᵃ</td>
</tr>
<tr>
<td>1 t/ha</td>
<td>1.75ᶜ</td>
<td>1.38ᶜ</td>
<td>77.50ᶜ</td>
<td>190.19ᵃ</td>
<td>0.95ᵃ</td>
</tr>
<tr>
<td>2 t/ha</td>
<td>1.80ᵇᶜ</td>
<td>1.88ᵇᶜ</td>
<td>78.00ᵇ</td>
<td>125.76ᵇ</td>
<td>0.99ᵃ</td>
</tr>
<tr>
<td>3 t/ha</td>
<td>1.85ᵇᶜ</td>
<td>2.21ᵃ</td>
<td>80.00ᵇ</td>
<td>122.74ᵇ</td>
<td>1.02ᵃ</td>
</tr>
<tr>
<td>4 t/ha</td>
<td>2.05ᵃ</td>
<td>2.38ᵃ</td>
<td>85.50ᵃ</td>
<td>103.52ᵃ</td>
<td>1.02ᵃ</td>
</tr>
</tbody>
</table>

Means with different letters on the same column are significantly different (p < 0.05)
Conclusion
This study shows that increase in the levels of poultry manure resulted in an increase in dry matter, starch, fibre and protein contents and a decrease in fat content of *D. bulbifera*. Optimum mineral content was observed at 2 t/ha level of poultry manure application. Starch, dry matter, fibre and protein were highest at 4 t/ha level of application. Functional properties such as WAC, OAC and gelatinization temperature increased with increase in level of poultry manure application. However, swelling index decreased with increase in poultry manure application and the bulk density was not significantly affected by poultry manure application.

References


