Chemical Constituents of Essential Oil from the Leaves of *Ipomoea batatas* L. (Lam.)

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Authors’ contributions

This work was carried out in collaboration between authors. Authors AROO and IAO designed the study. Author MAA preformed the collection of plant while author EI carried out the extraction of the oil. Author IAO managed the literature search and wrote the first draft of the manuscript with assistance from author AROO. All authors read and approved the final manuscript.

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ABSTRACT

The essential oil, obtained by hydrodistillation in an all glass Clevenger apparatus, from the air-dried leaves of *Ipomoea batatas* L. (Lam.) growing in Nigeria was analyzed by gas chromatography-flame ionization detector (GC-FID) and gas chromatography coupled with mass spectrometry (GC/MS). Forty-one constituents representing 93.5% of the oil were identified from the GC/MS spectra. Monoterpenes (22.0%), sesquiterpenes (46.5%) and diterpenes (22.5%) were the classes of compounds identified in the oil. The main constituents of the oil were abietadiene (8.9%), β-caryophyllene (8.8%), abiet-8,11,13-triene (7.1%), trans-(Z)-α-bergamotol (6.0%), cis-sabinene (5.5%) and spathulenol (5.3%). This is the first report on the chemical composition of essential oil of *I. batatas* growing in Nigeria.

Aims: The aim of the research is to investigate the volatile constituents from *I. batatas* collected in...
Ibadan, Oyo State, Nigeria

Study Design: Extraction of essential oil from the air-dried leaf samples of *I. batatas* and investigation of its chemical constituents.

Place and Duration of Study: Mature leaves of *I. batatas* were collected from a location in Ibadan, Oyo State, Nigeria, in May 2012.

Methodology: Air-dried and pulverized leaves were hydrodistilled in a Clevenger-type apparatus to obtain colourless volatile oil whose chemical constituents was analyzed by GC and GC/MS.

Results: A total of Forty-one compounds accounting 93.5% of the oil were identified from the GC/MS and the major constituents were found to be abietaadiene (8.9%), β-caryophyllene (8.8%), abieta-8,11,13-triene (7.1%), trans-(Z)-α-bergamotol (6.0%), cis-sabinene (5.5%) and spathulenol (5.3%).

Conclusion: The present oil compositions were found to be different from the results previously reported from the essential oils of different cultivars grown in other parts of the world.

Keywords: *Ipomoea batatas*; convolvulaceae; essential oil composition; terpenes.

1. INTRODUCTION

The sweet potato, *Ipomoea batatas* (L.) Lam. from the family Convolvulaceae is an herbaceous perennial vine that has white and purple flowers, large nutritious storage roots and heart-shaped, lobed leaves [1]. It is consumed as vegetables, commonly eaten as root crops in tropical areas and used as a folk medicine in several countries of the world. It was reported that *I. batatas* is the single most important dietary herb that would replace fatty foods [1]. The sweet potato represents the seventh most important food crop in the world. Traditionally, decoctions of the roots and leaves of *I. batatas* are used in the treatment of urinary infections, fever, skin diseases, diabetes, curing boils and acne. The sweet potato harvested when the production of premium-sized roots is maximised. There are several cultivars of *I. batatas*.

*Ipomoea batatas* is exceptionally rich in a variety of valuable protective nutrients [2-5]. It is a source of ascorbic acid, β-carotene, proteins and free sugars [6,7]. Extracts and compounds from *I. batatas* are known for their biological potentials. Anthocyanins from purple sweet potato have stronger binding ability with DNA [8] and possess antioxidant, antimutagenic and antiproliferative activities [9,10]. In addition, the anthocyanins also exhibited protective effects on damages of thymocytes caused by the Co^{60} irradiation [11] and inhibitory effect on transplantation tumor of mice [12]. Extracts from the plant improve insulin sensitivity in insulin-resistant rats [13] and displayed antibacterial [14-16], antidiabetic [17] and anti-neuroinflammatory [1] activities. The plant is a source of anti-diabetic flavones [18]. Aldose reductase inhibitors were characterized from the plant [19]. Extracts from *I. batatas* may be used as potential supportive treatment for thrombocytopenic disorders [20]. A review on pharmacological and phytochemical studies on *I. batatas* has been published [21].

The aerial parts of *I. batatas* produced resin glycosides, ipomotasides A, B, C, and D [22]. The plant contained galactolipids [23], nonacylated cyanidin 3-sophoroside-5-glucoside [9] and alkyd resin [24]. Other phytochemicals include caffeic acid and chlorogenic acid, β-sitosterol, scopoletin, cis-methylcaffeate, trans-methylcaffeate, cis-ethylcaffeate, trans-ethyl caffeate, scopolin and adenosine [25,26]. Quercetin-3-o-β-D-glucopyranosyl(6→1)-o-α-L-rhamnopyranosido, kaempferol-4,7-dimethylene, quercetin-3-o-β-D-glucoside and quercetin have been isolated from the plant [27]. In addition, 3,4-di-O-coffeoylquinic acid, 3,5-di-O-coffeoylquinic acid, 4,5-di-O-coffeoylquinic acid and 3,4,5-tri-O-coffeoylquinic acid were also obtained from the plant [28]. 4-Ipomoanol, an anti-cancer and anti-neoplastic agent is a natural product isolated from *I. batatas* [29,30].

In continuation of our research into the volatile constituents of Nigeria flora [31], we report in this paper the compounds identified in the essential oil of the leaves of *I. batatas*, which has not been published previously.

2. MATERIALS AND METHODS

2.1 Plant Material

Fresh and mature leaves of *I. batatas* were collected from plants growing at a location in Ibadan, Oyo State, Nigeria, in May 2012. Botanical identification of the plant material was carried out at the Herbarium, Forestry Research
Institute of Nigeria (FRIN), Ibadan, where a voucher specimen was deposited.

2.2 Oil Isolation

The air-dried and pulverized leaves of *I. batatas* (500 g) were subjected to hydrodistillation in a Clevenger-type glass apparatus for 3 h in accordance with the British Pharmacopoeia specification [32]. The oil collected was preserved in a sample tube and stored under refrigeration until moment of analysis.

2.3 Gas Chromatography (GC) Analysis

GC analysis of the oil was carried out on a Hewlett Packard HP 6820 Gas Chromatograph equipped with a FID detector and HP-5 column (60 m x 0.25 mm id), film thickness was 0.25 μm and the split ratio was 1:25. The oven temperature was programmed from 50°C (after 2 min) to 240°C at 5°C/min and the final temperature was held for 10 min. Injection and detector temperatures were maintained at 200°C and 240°C, respectively. Hydrogen was the carrier gas at a flow rate of 0.5 mL/s. An aliquot (0.5 μL of the diluted oil in hexane) was injected into the GC. Peaks were measured by electronic integration. A homologous series of *n*-alkanes were run under the same conditions for determination of retention indices. The relative amounts of individual components were calculated based on the percentage relative area (FID response) without using correction factors.

2.4 Gas Chromatography- Mass Spectrometry (GC/MS) Analysis

GC-MS analysis of the oil was performed on a Hewlett Packard Gas Chromatograph HP 6890 interfaced with Hewlett Packard 5973 mass spectrometer system equipped with a HP 5-MS capillary column (30 m x 0.25 mm id, film thickness 0.25 μm). The oven temperature was programmed from 70- 240°C at the rate of 5°C/min. The ion source was set at 240°C and electron ionization at 70eV. Helium was used as the carrier gas at a flow rate of 1 mL/min. Scanning range was 35 to 425 amu. Diluted oil in *n*-hexane (1.0 μL) was injected into the GC/MS.

The constituents of essential oil were identified as previously described [31].

3. RESULTS AND DISCUSSION

The identities of the forty-one compounds present in *I. batatas* as well as their percentage composition could be seen in Table 1. The yield of the essential oil was 0.23% (v/w) calculated on a dry weight basis. The oil sample was colourless. Monoterpene compounds constituted 22.0% of the total oil contents. The significant compounds among the monoterpenes were cis-sabinene (5.5%) and terpinen-4-ol (3.9%). The sesquiterpene compounds totaling 46.5% were represented mainly by β-caryophyllene (8.8%), trans-(Z)-α-bergamotol (6.0%) and spathulenol (5.3%). Diterpenes are also prominent in the oil (22.5%). The major constituents in this class are abietadiene (8.9%) and abieta-8,11,13-triene (7.1%). The other significant constituents of the oil were terpinen-4-ol (3.9%), β-elemene (3.6%), cembrene (3.4%), α-caryophyllene (2.8%), dehydroabietinol (2.8%), δ-selinene (2.7%), γ-terpinene (2.6%), trans-α-bergamotene (2.4%), p-menth-1-ene (2.2%) and allo-aromadendrene (2.1%). It was observed that α-copaene, α-humulene and γ-cadinene which were present in the leaf oil of *I. batatas* from USA were not detected in the Nigerian sample. [33].

Previous analyses on essential oils of *I. batatas* from other parts of the world have reported with most concentrated on tubers. A comparison of the present result with previously analysed samples of *I. batatas* revealed some qualitative and quantitative variations. For example, phenylacetaldehyde the main compound of *I. batatas* L. cv Ayamurasaki [34] was not identified in this sample while the content of *n*-hexadecanoic Nigerian sample was also insignificant. In addition, linoleic acid and 4-methyl-1-(2,3,4,5-tetrahydro-5-methyl[2.3′-bifuran]-5-yl)-2-pentanone, the main constituents of *I. batatas* L. cv Beniazyma and *I. batatas* L. cv Simon [34] respectively are conspicuously absent in the present oil sample. Other compounds such as 2-acetyl furan, 2-pentyl furan, 2-acetyl pyrrole, maltol (caramel odor), geraniol, methyl geranate and β-ionone that were not known to contribute to the odor of baked potato samples [35,36] were not identified in the present study. In addition, some compounds such as palmitic acid, 1-nonadecanol, 3-furaldehyde and 2-furmethanol which were present in some cultivars' of sweet potato were not identified in our study [37]. However, compounds such as α- and β-caryophyllene, β- and γ-elemene that were detected in a Chinese oil sample [38] were also present in the Nigerian grown oil sample.
Table 1. Chemical composition of essential oil of *I. batatas*

| Compounds            | RI (Cal.) | RI (Lit.) | % Composition |
|----------------------|-----------|-----------|---------------|
| α-Thujene            | 930       | 926       | 0.5           |
| α-Pinene             | 939       | 932       | 1.2           |
| 1-Octen-3-ol         | 974       | 974       | 0.6           |
| cis-Sabinene         | 976       | 974       | 5.5           |
| β-Pinene             | 980       | 976       | 2.4           |
| δ-2-Carene           | 1003      | 1001      | 1.5           |
| p-Menth-1-ene        | 1017      | 1017      | 2.2           |
| p-Cymene             | 1024      | 1022      | 0.4           |
| Limonene             | 1032      | 1024      | 0.9           |
| 1,8-Cineole          | 1036      | 1032      | 0.9           |
| γ-Terpinene          | 1061      | 1056      | 2.6           |
| Terpinen-4-ol        | 1177      | 1174      | 3.9           |
| Bicycloelemene       | 1336      | 1338      | 0.4           |
| Eugenol              | 1358      | 1356      | 0.6           |
| β-Panasinsene        | 1383      | 1381      | 0.6           |
| β-Elemene            | 1389      | 1389      | 3.6           |
| β-Cuvebene           | 1390      | 1391      | 0.4           |
| Longifolene          | 1409      | 1407      | 1.5           |
| α-Caryophyllene      | 1410      | 1408      | 2.8           |
| β-Caryophyllene      | 1419      | 1417      | 8.8           |
| trans-α-Bergamotene  | 1430      | 1431      | 2.4           |
| γ-Elemene            | 1437      | 1434      | 0.5           |
| allo-Aromadendrene   | 1460      | 1458      | 2.1           |
| γ-Gurjunene          | 1477      | 1475      | 1.4           |
| β-Chamigrene         | 1478      | 1476      | 1.3           |
| Eudesma-4(14),7(11)-diene | 1479 | 1479 | 0.7         |
| δ-Selinene           | 1495      | 1492      | 2.7           |
| Bicyclogermacrene    | 1500      | 1500      | 3.3           |
| (E,E)-α-Farnesene    | 1505      | 1505      | 0.4           |
| δ-Cadinene           | 1525      | 1522      | 0.3           |
| Spathulenol          | 1578      | 1577      | 5.3           |
| Caryophyllene oxide  | 1583      | 1581      | 1.7           |
| α-Santalol           | 1671      | 1671      | 0.3           |
| trans-(Z)-α-Bergamotol | 1690  | 1690      | 6.0           |
| Cembrene             | 1930      | 1929      | 3.3           |
| n-Hexadecanoic acid  | 1960      | 1959      | 0.8           |
| Labda-8(20),12,14-triene | 2006 | 2004      | 0.3           |
| Abieta-8,11,13-triene | 2073     | 2073      | 7.1           |
| Abietadiene          | 2090      | 2087      | 8.9           |
| Octadecanoic acid    | 2160      | 2158      | 0.5           |
| Dehydroabietinol     | 2354      | 2354      | 2.8           |
| Total                |           |           | 93.5          |

| Compounds                | % Composition |
|--------------------------|---------------|
| Monoterpene hydrocarbons | 17.2          |
| Oxygenated monoterpene   | 4.8           |
| Sesquiterpene hydrocarbons | 33.2        |
| Oxygenated sesquiterpene | 13.3          |
| Diterpenes               | 22.5          |
| Phenylpropanoids         | 0.6           |
| Fatty acids              | 1.3           |
| Others                   | 0.6           |

*a Elution order on DB-5 column; RI (Lit.) = Literature retention indices; RI (Cal.) = Retention indices relative to C₉-C₂₄ n-alkanes on the HP-5 column*
The volatile components of other *Ipomoea* plants have been reported. The main constituents of *I. pes-caprae* [39] were 8-cedren-13-ol (13.0%), (E)-nerolidol (7.0%), guaiol (6.2%), α-cadinol (6.2%) and limonene (6.1%) in fresh leaves and β-caryophyllene (36.6%), α-copaene (8.0%), germacrene D (7.3%), phytol (5.8%), δ-cadinene (5.7%) and α-humulene (5.4%) in the dried leaf samples. The composition of the essential oil of *I. aquatica* comprised mainly of phytol (37.08%), palmic acid (10.99%) and (Z)-3-hexen-1-ol (5.7%) [40]. Linalool (27.5%) was the main component of *I. bracteata* [41].

A study has shown that the sweet potato weevil (*Cylas formicarius elegantulus*) could readily orient in the dark to the volatile phytochemicals emanating from the plant parts placed in their vicinity. The females are attracted by the volatiles emanating from the leaves and storage roots while the males are attracted by leaf volatiles but little attracted by those emanating from the storage roots. This suggested that there are qualitative and/or quantitative variations in the volatile compounds present in the different parts of *I. batatas* [33]. This may have been responsible for the observed compositional variations in the volatile oils of this plant from Nigeria and elsewhere.

4. CONCLUSION

The chemical compositions of essential oil from the leaves of *I. batatas* grown in Nigeria are being reported for the first time. It was found that the compositional pattern was different from previous studies on the essential oils from the tubers of different cultivars of this plant as well as those from other member of the genus. This may be attributable to the fact that different parts of the same plant contained different phytochemicals. In additional factors such as the ecological and climatic conditions as well nature and age of the plant, period of collection, handling procedures etc may contribute to the different nature of the compounds obtained from the essential oil.

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CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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