METABOLITE PROFILING OF SELECTED COMMONLY CONSUMED GREEN LEAFY VEGETABLES IN SOUTHWESTERN NIGERIA

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Abstract: This study was aimed at unveiling the phytoconstituents of ten selected underexploited leafy vegetables which were Jatropha tanjorensis, Solanum nigrum, Talinum triangulare, Solanecio biafrae, Vernonia amygdalina, Crassocephalum crepidoides, Telfairea occidentalis, Amaranthus hydridus, Launaea taraxacifolia, and Solanum macrocarpon. Freshly harvested leafy vegetables were processed separately, oven dried and blended into fine powder. GC-MS analysis was carried out on the methanolic extract using standard procedures. The GC-MS analysis of the leafy vegetables shows revealed the presence of 27 phytochemical constituents in Jatropha tanjorensis and Solanum nigrum, 31 in Crassocephalum crepidoides, 20 in Solanum macrocarpon, 23 in Solanecio Biafrae and Talinum triangulare, 22 in Vernonia amygdalina, 28 photochemical constituents in Amaranthus hybridus and Launaea taraxacifolia and 32 in Telfairea occidentalis. The results also showed that the compounds belonging to the fatty acid, carboxylic acid and phenolic compounds were predominant constituents. All the vegetable samples contain n-Hexadecanoic acid at appreciable concentration. The studied leafy vegetables produce a wide variety of bioactive compounds. These compounds have potential applications in biomedical, pharmaceutical and agricultural industries.

Keywords: Vegetables, medicine, food, plants, phytochemical

Introduction

Leafy Vegetables are herbaceous plants, annual or perennial plant whose leafy portion or whole plants can be consumed raw or cooked in order to obtain potentially health helping compounds for effective growth and protection of the body against foreign factors or diseases (Hughes, 2013). Leafy vegetables constitute the major proportion of the diet of the populace in many parts of the world and mostly in Africa and Asia strongly due to their increasing public awareness on their derived health benefits. Current research has linked the consumption of leafy vegetable that are rich in diets to reduced incidence of cardiovascular diseases, ischemic heart disease, stroke cases, body stress (Lin et al., 2009), anticancerous (Rajasekaran et al., 2014; Choudhury, 2012), antimicrobial (Roy et al., 2013; Vijayasanthi and Doss, 2015; Srinivasan et al., 2011), haepatoprotective (Sharmila Banu et al., 2009) and anti-inflamatory (Kaushik et al., 2011).

Wild vegetables which are underutilized serve as vital sources for the supplementation of macro and micronutrients in vegetarian diets (Nordeid et al., 1996). Moreover, some of the plants are reported to be haepatoprotective (Sharmila Banu et al., 2009), anti-inflamatory (Kaushik et al., 2011) and more. By tradition among tribes and nomadic people, they are used as natural healers, antiulcer, febrifuge, abortifacient, diuretic, galactagogue, cholegogue, memory enhancer, antihyperglycemic (Senthilkumar et al., 2014; Shanmugam et al., 2012). With great medicinal and pharmacological potential, underutilized leafy Vegetables are well known widely for possessing great utility and usage in folklore medicines and medicinal herbs. With the presence of several compounds such as beta sitosterol glucoside, spinasterol, beta sitosterol, campesterol, saponinsstigmasterol, β-sitosterol, β-sitosterol, oleanolic acid and stearic acid etc., they are known to be good source for pharmaceuticals food additives, flavors and others industrial values.

In recent years, a gradual increase is observed in the use of some underutilized leafy vegetables such as medicinal plants, as they are recognized as potentially safe drugs and are of valuable importance in terms of natural resources. These leafy plants have been analyzed to play a vital role in moldering therapeutics, medicine and pharmacology. Depending upon the chemical compounds produce from these vegetables, some specific physiological action of these plants on human body and the medicinal value of these plants are identified (Dangol, 2008; Dattatraya et al., 2012). Therefore, more than 60% of these unexploited vegetables are used as medicinal plants for health care in both pediatrics and geriatrics (Bal, 2003). Few studies on the metabolites profile and elucidation of medicinal and pharmacological uses of underutilized leafy vegetables have been reported (Sukumal, 2007). This study will therefore aim at unveiling the phytoconstituents of under exploited leafy vegetables such as Amaranthus hybridus, Crassocephalum crepidoides, Jatropha tanjorensis, Launaea taraxacifolia, Solanum nigrum, Solanum macrocarpon, Solanecio biafrae, Talinum triangulare, Telfairea occidentalis, and Vernonia amygdalina, and clarify their medicinal and pharmacological potentials.

Materials and Methods

The selected underutilized vegetables were bought from Owode market, Oja Oba market, Sasha market, Igbona market and their environment in Osogbo, Osun State, Nigeria (Plate 1-10). The vegetables were identified, authenticated and deposited in the Laboratory of Department of Plant Biology, Osun State University, Osogbo, Nigeria. The samples were properly washed under tap water, oven-dried in an air

circulating oven at 70^0 C, blended into powder and preserved in a tightly sealed containers for further analysis.

The samples were properly washed under tap water, oven dried in an air circulating oven at 70^0C, blended into a powder using a blender and preserved in a tightly sealed containers for extraction. Analysis was done using a Varian 3800/4000 gas chromatograph mass spectrometer equipped with an Agilent equipped with a VF-5MS column (30.0m x 0.25mm, 0.25µm film thickness). GC-MS system settings were as follows: the initial column temperature was 100 ∘C for 1 min, then ramped at 30^0C to 270^0C, and finally held at 270^0C for 10 min. The temperatures of the transfer line, ion trap, and quadrupole were 280, 230, and 150^0C, respectively. The inlet temperature was 270^0C, and a 20 μL sample was injected. Nitrogen with 99.9995% purity was used as carrier gas with a constant flow of 1.0 ml/min. After GC-MS separation, all the peaks were compared with the standard structural library to determine probable phytochemical composition of the samples. The MS scan range was set from 40-800 Da.

The relative amount (%) of each component was calculated by comparison its average Peak area to the total areas. Organic compounds in the samples were identified in Wiley's NIST 08 Mass Spectral Library, if the obtained comparison scores were higher than 95%. Otherwise, fragmentation peaks of the compounds were evaluated, and the compounds were identified using the memory background for the identification of the compounds that appeared in GC-MS chromatograms. Contents of individual compound in the extract were given in percent of the total compound in the sample. This was the standard way to quantify most organic compounds in the samples. The chromatograms obtained from the total ion count (TIC) were integrated without any correction for co-eluting peaks and the results were expressed as total abundance. All the peaks were identified based on mass spectral matching (≥ 90%) from both the NIST and Wiley libraries. Only compounds with 90% or greater spectral matching accuracy are reported. No response factors were calculated.

All the samples and replicates were continuously injected as one batch in random order to discriminate technical from biological variations. Additionally, the prepared pooled samples were used as quality controls (QCs), which were injected at regular intervals throughout the analytical run to provide a set of data from which the repeatability can be assessed.

Plate 1: *Amaranthus hybridus*

Plant 2: *Crassocephalum crepidiodies*

Plate 3: *Jatropha tranjoresis*

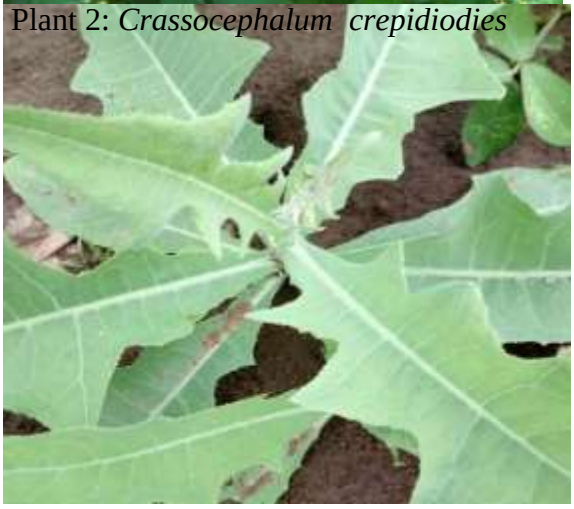

Plate 4: *Launaea taraxacifolia*

Plate 5: *Solanum nigrum*

Plate 6: *Solanum macrocarpon*

Plate 7: *Solanecio biafrae*

Plate 8: *Talinum triangulare*

Plate 9: *Telfaria occidentials*

Plate 10: *Vernonia amygdlina*

Results

The GC-MS analysis of fractions of Jatropha tanjorensis leaves revealed the presence of twenty seven (27) compounds respectively. These compounds majorly belong to metabolic group such as carboxylic acid, phenolic compounds, fatty acid and methyl ester. The five most abundant of the twenty-seven (27) compounds include n-Hexadecanoic acid with peak area value of 13.05%, 9,12,15-Octadecatrienoic acid with peak area value of 9.6%, Benzeneacetic acid with peak area value of 8.74%, Methyl stearate with peak area value of 8.46%, and Benzoic acid with peak area value of 5.77%. 1,3,5-Benzenetriol with a peak area value of 0.29%, Salicylic acid with peak area value of 0.31%, Myo-Inositol with peak area value of 0.55%, vanillic acid with peak area value of 0.62,

Squalene with peak area value of 0.89%, and 2-Propenoic acid with peak area value of 0.89% were detected at minute quantity (Table 1).

GC-MS analysis performed on the methanolic extract of Crassocephalum crepidoides revealed that thirty one compounds were present as shown in Table 2. The five most abundant of the nine compounds with their peak area value include n-Hexadecanoic acid (9.14%), Methyl tetradecanoate (7.77%), 3,5-Dimethoxy-4-hydroxycinnamic acid and 13-Docosenamide with the same peak area value (9.14%), Methyl stearate (7.45%), and 1,2-Benzenedicarboxylic acid, diheptyl ester (9.14%). Glucose (0.24%), 2-Propenoic acid (0.49%), Myo-Inositol (0.52%), Sorbitol (0.62%), and trans-Ferulic acid (0.68%) were detected at minute quantity. Most of the compounds isolated in Crassocephalum crepidoides belong to metabolic group such as Carboxylic acid, Aldehyde and Polyol. Most phytochemical constituents identified in Solanum macrocarpon (Table 3) and Solanecio Biafrae (Table 4) were fatty acids and phenolic compounds. The GC-MS analysis of fractions of Solanum macrocarpon leaves revealed the presence of twenty (20) compounds and the fractions obtained in Solanecio Biafrae revealed the presence of twenty three (23) compounds. The five most abundant of the compounds twenty (20) compounds obtained from Solanum macrocarpon with their peak area value include n-Hexadecanoic acid (11.67%),2-Propenoic acid (9.53%), Myo-Inositol (9.39%),1,2-Benzenedicarboxylic acid (5.89%), and 9,12,15-Octadecatrienoic acid (5.38%). The most abundant of the compounds obtained from Solanecio Biafrae were Tetradecanoic acid (8.58%),9,12,15-Octadecatrienoic acid (20.65%), Octadecanoic acid (19.74%), Methyl stearate (17.17%), 13-Docosenamide (9.53%). Other compounds were present at very low concentration.

GC-MS analysis of the methanolic extract of Talinum triangulare (Table 5), Vernonia amygdalina (Table 6) and Solanum nigrum (Table 7) revealed the presence of twenty three (23), twenty three (22), and twenty seven (23) compounds. A large proportion of the compounds obtained from Talinum triangulare were carbohydrates, fatty acids and phenolic compounds, those obtained from Vernonia amygdalina and Solanum nigrum were mostly fatty acids and Hydroxycinnamic acid. The most abundant of the compounds obtained from Talinum triangulare were n-Hexadecanoic acid (32.93%), Methyl stearate (9.29%), and Tetradecanoic acid (9.53%). In Vernonia amygdalina, n-Hexadecanoic acid (22.54%), 2-Propenoic acid (10.88%), propionic acid (10.15%), and Glucose (6.74%) were most abundant, while in and Solanum nigrum, 13-Docosenamide (7.89%), Hexadecanal (7.88%), p-Coumaric acid (10.15%), and Caffeic acid were mostly present.

The results of the GC-MS analysis of the methanolic extract revealed that twenty-eight (28) compounds were isolated from Amaranthus hybridus (Table 8) and Launaea taraxacifolia (Table 9), and thirty (30) compounds were isolated from Telfairea occidentalis (Table 10). Most of the compounds isolated from Amaranthus hybridus, Launaea taraxacifolia and Telfairea occidentalis belongs to phenolic and fatty acids. Octadecatrienoic acid (6.15%), Benzoic acid (5.93%), Methyl stearate (5.88%), and Myo-Inositol (4.07%) were present at a larger proportion in Amaranthus hybridus. Benzaldehyde (8.45%), propionic acid (4.99%), Caffeic acid (5.03%), and trans-Ferulic acid (4.98%) were found in Launaea taraxacifolia at an appreciable amount. In Telfairea occidentalis, Benzeneethanol (6.49%), 2-Propenoic acid (5.93%), Benzoic acid (5.65%), trans-Ferulic acid (5.47%), and Caffeic acid (5.44%) were identified to be present in large proportion.

Discussion

The GC-MS analysis of the leafy vegetables revealed the presence of 27 phytochemical constituents in Jatropha tanjorensis and Solanum nigrum, 31 in Crassocephalum crepidoides, 20 in Solanum macrocarpon, 23 in Solanecio Biafrae and Talinum triangulare, 22 in Vernonia amygdalina, 28 photochemical constituents in Amaranthus hybridus and Launaea taraxacifolia and 32 in Telfairea occidentalis. The active principles of the compounds with their peak area in percentage shows that the peak area of Jatropha tanjorensis ranges from 0.29 to 13.05%, Crassocephalum crepidoides ranges from 0.24 to 9.14%, Solanum nigrum ranges from 1.57 to 11.67%, Solanecio Biafrae ranges from 0.41 to 20.65%, Talinum triangulare ranges from 0.64 to 32.93%, Vernonia amygdalina ranges from 0.42 to 22.54%, Solanum nigrum ranges from 0.23 to 7.89%, Amaranthus hybridus ranges from 0.39 to 8.32%, Launaea taraxacifolia ranges from 0.82 to 11.87%, while that of Telfairea occidentalis ranges from 0.57 to 6.49%. A huge variety of secondary compounds isolated in these leafy vegetables and at high proportion implies that these plants produce a huge variety of secondary compounds that serves as natural protection against microbial and insect attack. Some of these compounds are also toxic to animals, but others may not be toxic. Indeed, many of these compounds have been used in the form of whole plants or plant extracts for food, biomedical applications or medical applications in man (Bibu et al., 2010). The potential of these compounds are beneficial as food and feed additives.

The GC-MS analysis among the leafy vegetables also revealed that the compounds belonging to the Fatty acid, carboxylic acid and phenolic compounds were predominant constituents that contribute to the antioxidant, antimicrobial, antitumor, cancer-preventive, hypocholesterolemic, nematicide, pesticide, antiandrogenic, hemolytic, 5-alpha reductase inhibitor, lubricant and flavor activities. Fatty acid and pheolic compounds were also used in the manufacture of a wide variety of products such as personal care products, antifungal agent, hair/skin care products, antiperspirants and deodorants. Previous studies showed that Fatty acid and phenolic compounds are well known antimicrobial compound isolated from different plant species 39, 40 and fungal species (Patel and Patel, 2016). Compounds belonging to the carboxylic acid group were used in food packaging, laundry and dishwashing products and have also been approved as active and non-active ingredients in pharmaceuticals (Phadungkit et al., 2012).

The methanolic extract of all the leafy vegetables revealed that all the plants contains n-Hexadecanoic acid at appreciable concentration. Meanwhile, it is present in abundance in Jatropha tanjorensis, Crassocephalum crepidoides, Solanum macrocarpon, Talinum triangulare and Vernonia amygdalina. n-Hexadecanoic is thought to have antibacterial, anticarcinogenic, anti-inflammatory, antioxidant and local anesthetic properties, well as the ability to alter immunological responses directly on T cells (Aparna et al., 2012; Shaaban et al., 2021) (Legault and Pichette, 2007). It is an important industrial chemical that may be used as precursor of vitamins

E and K and also as a cholesterol lowering agent (Aparna et al. (2012). The antioxidant properties enable the prevention of oxidation of free radicals in the body, the antimicrobial properties prevents therapeutic properties.

The presence of some carboxylic acid derivatives such as Caffeic acid, Benzoic acid, Vanillic acid, and Salicylic acid may enhance the activity of the plants. These compounds have the ability to scavenge the reacting oxygen species (ROS) and that may result in the relief of patients with growth of tumours (Adewole and Ojewole, 2009). Monosaccharide such as glucose and fructose, Fatty acid ester such as Methyl stearate, Polyol such as sorbitol, and Terpene such as squalene were also present in the leafy vegetables and have been proven to act as anti-parasitic, insecticidal, anti-ulcer, skin enhancer, anti-tumor, and anti-nociceptive (Viera et al., 2010; Chan et al. (2016).

Conclusion

The studied leafy vegetables produce a wide variety of bioactive compounds. These compounds have potential application in biomedical, pharmaceutical and agricultural industries. These chemical constituents present in Jatropha tanjorensis, Solanum nigrum, Talinum triangulare, Solanecio Biafrae, Vernonia amygdalina, Crassocephalum crepidoides, Telfairea occidentalis, Amaranthus hybridus, Launaea taraxacifolia, and Solanum macrocarpon plant support their use in herbal medicine as anti-viral, antitumour, antibacterial, analgesic, anti-fungal, hypotensive, anthelmintic, antiinflammatory, immune enhancing, wound-healing, anticarcinogenic, anti-malarial, anticonvulsing, anti-diarrhoea, antiparasitic and anti-anxiety effects (Moghadamtousi et al., 2015). The identified chemical constituents from these leafy vegetables by GC-MS give the plants the pharmacological properties like; antioxidant, antimicrobial, antiallergic, antifungal, anticarcinogenic, anti-depressing with other pharmacological activities.

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Table 1: Metabolite content of the methanolic extract of *Jatropha tanjorensis*

Peak ǂ	Metabolite Group	**Compound Detected**	**Mol. Formula**	**Peak Area (%)**
1	Benzaldehyde	Benzaldehyde, 4-hydroxy-	$C_7H_6O_2$	2.09
2	Trihydroxybenzene	1,3,5-Benzenetriol	$C_6H_6O_3$	0.29
3	Carboxylic acid	Salicylic acid	$C_7H_6O_3$	0.31
4	Phenol	Benzeneethanol, 4-hydroxy-	$C_8H_{10}O_2$	1.13
5	Ketose, Hexose	Fructose	$C_6H_{12}O_6$	1.07
6	Pyranone, Diol	4H-Pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-methyl-	$C_6H_8O_4$	5.69
7	Carboxylic acid	Vanillic acid	$C_8H_8O_4$	0.62
8	Polyol	Myo-Inositol	$C_6H_{12}O_6$	0.55
9	Aldehyde, Phenol	Benzaldehyde, 4-hydroxy-3,5-dimethoxy-	$C_9H_{10}O_4$	1.76
10	Carboxylic acid, Cinnamic acid	p-Coumaric acid	$C_9H_8O_3$	3.57
11	Carboxylic acid, Phenol	2-Propenoic acid, 3-(3-hydroxyphenyl)-	$C_9H_8O_3$	0.89
12	Aldose, Hexose	Glucose	$C_6H_{12}O_6$	1.90
13	Carboxylic acid, Phenol	Benzeneacetic acid, 4-hydroxy-	$C_8H_8O_3$	8.74
14	Polyol	Sorbitol	$C_6H_{14}O_6$	1.76
15	Fatty acid, Polyunsaturated fatty acid	9,12-Octadecadienoic acid (Z,Z)-	$C_{18}H_{32}O_2$	5.64
16	Fatty acid, Polyunsaturated fatty acid	9,12,15-Octadecatrienoic acid, (Z,Z,Z)-	$C_{18}H_{30}O_2$	9.66
17	Carboxylic acid, Phenol	Caffeic acid	$C_9H_8O_4$	3.72
18	Fatty acid	n-Hexadecanoic acid	$C_{16}H_{32}O_2$	13.05
19	Carboxylic acid, Phenol	Benzoic acid, 4-hydroxy-3,5-dimethoxy-	$C_9H_{10}O_5$	5.77
20	Fatty acid	Tetradecanoic acid	$C_{14}H_{28}O_2$	5.54
21	Carboxylic acid, Phenol	β-(4-Hydroxy-3-methoxyphenyl)propionic acid	$C_{10}H_{12}O_4$	4.45
22	Fatty acid ester, Methyl ester	Methyl tetradecanoate	$C_{15}H_{30}O_2$	3.18
23	Fatty acid ester, Methyl ester	Methyl stearate	$C_{19}H_{38}O_2$	8.46
24	Aldehyde, Fatty aldehyde	Hexadecanal	$C_{16}H_{32}O$	4.65
25	Fatty amide	13-Docosenamide, (Z)-	$C_{22}H_{43}NO$	2.58
26	Phthalate ester	1,2-Benzenedicarboxylic acid, diheptyl ester	$C_{22}H_{34}O_4$	1.91
27	Triterpenoid	Squalene	$C_{30}H_{50}$	0.86

Table 2: Metabolite content of the methanolic extract of *Crassocephalum crepidoides*

Peak #	Metabolite Group	Compound Detected	Mol. Formula	Peak Area (%)
1	Aldehyde	Benzaldehyde, 4-hydroxy-	$C_7H_6O_2$	0.45
2	Trihydroxybenzene	1,3,5-Benzenetriol	$C_6H_6O_3$	0.58
3	Carboxylic acid	Salicylic acid	$C_7H_6O_3$	1.37
4	Phenol	Benzeneethanol, 4-hydroxy-	$C_8H_{10}O_2$	2.52
5	Pyranone	4H-Pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6 methyl-	$C_6H_8O_4$	1.60
6	Ketose	Fructose	$C_6H_{12}O_6$	0.90
7	Carboxylic acid	Vanillic acid	$C_8H_8O_4$	2.54
8	Polyol	Myo-Inositol	$C_6H_{12}O_6$	0.52
9	Aldehyde	Benzaldehyde, 4-hydroxy-3,5-dimethoxy-	$C_9H_{10}O_4$	2.24
10	Carboxylic acid	p-Coumaric acid	$C_9H_8O_3$	0.91
11	Carboxylic acid	2-Propenoic acid, 3-(3-hydroxyphenyl)-	$C_9H_8O_3$	0.49
12	Aldose	Glucose	$C_6H_{12}O_6$	0.24
13	Carboxylic acid	Benzeneacetic acid, 4-hydroxy-	$C_8H_8O_3$	0.69
14	Carboxylic acid	Caffeic acid	$C_9H_8O_4$	3.26
15	Carboxylic acid	trans-Ferulic acid	$C_{10}H_{10}O_4$	0.68
16	Polyol	Sorbitol	$C_6H_{14}O_6$	0.62
17	Carboxylic acid	Benzoic acid, 4-hydroxy-3,5-dimethoxy-	$C_9H_{10}O_5$	0.74
18	Fatty acid	9,12-Octadecadienoic acid (Z,Z)-	$C_{18}H_{32}O_2$	6.42
19	Fatty acid	Tetradecanoic acid	$C_{14}H_{28}O_2$	3.09
20	Carboxylic acid	β-(4-Hydroxy-3-methoxyphenyl) propionic acid	$C_{10}H_{12}O_4$	3.11
21	Fatty acid ester	Methyl tetradecanoate	$C_{15}H_{30}O_2$	7.77
22	Fatty acid	n-Hexadecanoic acid	$C_{16}H_{32}O_2$	9.14
23	Fatty acid ester	Methyl stearate	$C_{19}H_{38}O_2$	7.45
24	Aldehyde	Hexadecanal	$C_{16}H_{32}O$	3.66
25	Fatty acid	9,12,15-Octadecatrienoic acid, (Z,Z,Z)-	$C_{18}H_{30}O_2$	5.55
26	Carboxylic acid	3,5-Dimethoxy-4-hydroxycinnamic acid	$C_{11}H_{12}O_5$	7.74
27	Fatty acid	Octadecanoic acid	$C_{18}H_{36}O_2$	3.50
28	Flavonoid	Quercetin	$C_{15}H_{10}O_7$	3.18
29	Fatty amide	13-Docosenamide, (Z)-	$C_{22}H_{43}NO$	7.74
30	Phthalate ester	1,2-Benzenedicarboxylic acid, diheptyl ester	$C_{22}H_{34}O_4$	7.39
31	Triterpenoid	Squalene	$C_{30}H_{50}$	3.84

Table 3: Metabolite content of the methanolic extract of *Solanum macrocarpon*

Peak #	Metabolite group	Compound Detected	Mol. Formula	Peak Area (%)
1	Aldehyde	Benzaldehyde, 4-hydroxy-	$C_7H_6O_2$	1.57
2	Triol	1,3,5-Benzenetriol	$C_6H_6O_3$	5.92
3	Carboxylic acid	Salicylic acid	$C_7H_6O_3$	1.60
4	Phenol	Benzeneethanol, 4-hydroxy-	$C_8H_{10}O_2$	2.22
5	Pyrone	4H-Pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-methyl-	$C_6H_8O_4$	1.11
6	Phenol	Benzeneacetic acid, 4-hydroxy-	$C_8H_8O_3$	2.96
7	Phenol	Vanillic acid	$C_8H_8O_4$	5.66
8	Phenol	Benzoic acid, 3,4-dihydroxy-	$C_7H_6O_4$	4.63
9	Carbohydrate	Myo-Inositol	$C_6H_{12}O_6$	9.39
10	Phenolic acid	2-Propenoic acid, 3-(3-hydroxyphenyl)-	$C_9H_8O_3$	9.53
11	Phenolic acid	p-Coumaric acid	$C_9H_8O_3$	2.30
12	Carbohydrate	Fructose	$C_6H_{12}O_6$	2.31
13	Phenolic acid	Caffeic acid	$C_9H_8O_4$	5.65
14	Polyol	Sorbitol	$C_6H_{14}O_6$	3.59
15	Fatty acid	n-Hexadecanoic acid	$C_{16}H_{32}O_2$	11.67
16	Fatty acid	Octadecanoic acid	$C_{18}H_{36}O_2$	7.76
17	Fatty acid ester	Methyl stearate	$C_{19}H_{38}O_2$	4.84
18	Fatty acid	9,12,15-Octadecatrienoic acid, (Z,Z,Z)-	$C_{18}H_{30}O_2$	5.38
19	Phthalate ester	1,2-Benzenedicarboxylic acid, diheptyl ester	$C_{22}H_{34}O_4$	5.89
20	Terpene	Squalene	$C_{30}H_{50}$	5.92

Table 4: Metabolite content of the methanolic extract of *Solanecio Biafrae*

Peak #	Metabolite Group	Compound Detected	Mol. Formula	Peak Area (%)
1	Aldehyde	Benzaldehyde, 4-hydroxy-	$C_7H_6O_2$	2.43
2	Triol	1,3,5-Benzenetriol	$C_6H_6O_3$	1.18
3	Carboxylic acid	Salicylic acid	$C_7H_6O_3$	0.78
4	Phenol	Benzeneethanol, 4-hydroxy-	$C_8H_{10}O_2$	0.98
5	Pyrone	4H-Pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-methyl-	$C_6H_8O_4$	0.41
6	Phenol	Benzeneacetic acid, 4-hydroxy-	$C_8H_8O_3$	0.42
7	Phenol	Vanillic acid	$C_8H_8O_4$	1.29
8	Phenol	Benzoic acid, 3,4-dihydroxy-	$C_7H_6O_4$	0.43
9	Carbohydrate	Myo-Inositol	$C_6H_{12}O_6$	2.54
10	Phenolic acid	2-Propenoic acid, 3-(3-hydroxyphenyl)-	$C_9H_8O_3$	1.72
11	Phenolic acid	p-Coumaric acid	$C_9H_8O_3$	0.86
12	Carbohydrate	Fructose	$C_6H_{12}O_6$	0.85
13	Phenolic acid	Caffeic acid	$C_9H_8O_4$	1.49
14	Fatty acid	9,12,15-Octadecatrienoic acid, (Z,Z,Z)-	$C_{18}H_{30}O_2$	20.65
15	Carbohydrate	Glucose	$C_6H_{12}O_6$	1.30
16	Fatty acid	Octadecanoic acid	$C_{18}H_{36}O_2$	19.74
17	Fatty acid ester	Methyl stearate	$C_{19}H_{38}O_2$	17.17
18	Polyol	Sorbitol	$C_6H_{14}O_6$	3.07
19	Phenol	Benzoic acid, 4-hydroxy-3,5-dimethoxy-	$C_9H_{10}O_5$	2.59
20	Fatty acid	Tetradecanoic acid	$C_{14}H_{28}O_2$	8.58
21	Amide	13-Docosenamide, (Z)-	$C_{22}H_{43}NO$	2.64
22	Phthalate ester	1,2-Benzenedicarboxylic acid, diheptyl ester	$C_{22}H_{34}O_4$	2.56
23	Terpene	Squalene	$C_{30}H_{50}$	5.33

Table 5: Metabolite content of the methanolic extract of *Talinum triangulare*

Peak #	Metabolite Group	Compound Detected	Mol. Formula	Peak Area (%)
1	Aldehyde	Benzaldehyde, 4-hydroxy-	$C_7H_6O_2$	1.32
2	Triol	1,3,5-Benzenetriol	$C_6H_6O_3$	4.49
3	Carboxylic acid	Salicylic acid	$C_7H_6O_3$	3.32
4	Phenol	Benzeneethanol, 4-hydroxy-	$C_8H_{10}O_2$	3.33
5	Pyrone	4H-Pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-methyl-	$C_6H_8O_4$	1.34
6	Phenol	Benzeneacetic acid, 4-hydroxy-	$C_8H_8O_3$	1.35
7	Phenol	Vanillic acid	$C_8H_8O_4$	1.36

8	Phenol	Benzoic acid, 3,4-dihydroxy-	$C_7H_6O_4$	1.40
9	Carbohydrate	Myo-Inositol	$C_6H_{12}O_6$	1.39
10	Phenolic acid	2-Propenoic acid, 3-(3-hydroxyphenyl)-	$C_9H_8O_3$	9.28
11	Phenolic acid	p-Coumaric acid	$C_9H_8O_3$	1.35
12	Fatty acid	9,12,15-Octadecatrienoic acid, (Z,Z,Z)-	$C_{18}H_{30}O_2$	6.34
13	Phenolic acid	Caffeic acid	$C_9H_8O_4$	3.38
14	Carbohydrate	Fructose	$C_6H_{12}O_6$	0.66
15	Carbohydrate	Glucose	$C_6H_{12}O_6$	0.65
16	Phenolic acid	β-(4-Hydroxy-3-methoxyphenyl)propionic acid	$C_{10}H_{12}O_4$	0.64
17	Phenol	Benzoic acid, 4-hydroxy-3,5-dimethoxy-	$C_9H_{10}O_5$	1.69
18	Polyol	Sorbitol	$C_6H_{14}O_6$	1.60
19	Fatty acid ester	Methyl stearate	$C_{19}H_{38}O_2$	9.29
20	Fatty acid	Tetradecanoic acid	$C_{14}H_{28}O_2$	4.04
21	Fatty acid	n-Hexadecanoic acid	$C_{16}H_{32}O_2$	32.93
22	Phthalate ester	1,2-Benzenedicarboxylic acid, diheptyl ester	$C_{22}H_{34}O_4$	4.14
23	Terpene	Squalene	$C_{30}H_{50}$	4.68

Table 6: Metabolite content of the methanolic extract of *Vernonia amygdalina*

Peak #	Metabolite Group	Compound Detected	Mol. Formula	Peak Area (%)
1	Aldehyde	Benzaldehyde, 4-hydroxy-	$C_7H_6O_2$	0.42
2	Trihydroxybenzene	1,3,5-Benzenetriol	$C_6H_6O_3$	0.43
3	Carboxylic acid	Salicylic acid	$C_7H_6O_3$	0.45
4	Phenol	Benzeneethanol, 4-hydroxy-	$C_8H_{10}O_2$	0.79
5	Pyrone	4H-Pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-methyl-	$C_6H_8O_4$	2.30
6	Phenol	Benzeneacetic acid, 4-hydroxy-	$C_8H_8O_3$	2.23
7	Carboxylic acid	Vanillic acid	$C_8H_8O_4$	1.05
8	Dihydroxybenzoic acid	Benzoic acid, 3,4-dihydroxy-	$C_7H_6O_4$	6.46
9	Carbohydrate	Myo-Inositol	$C_6H_{12}O_6$	2.86
10	Hydroxycinnamic acid	p-Coumaric acid	$C_9H_8O_3$	4.61
11	Hydroxycinnamic acid	2-Propenoic acid, 3-(3-hydroxyphenyl)-	$C_9H_8O_3$	10.88
12	Ketohexose	Fructose	$C_6H_{12}O_6$	0.92
13	Polyunsaturated fatty acid	9,12,15-Octadecatrienoic acid, (Z,Z,Z)-	$C_{18}H_{30}O_2$	15.21
14	Hydroxycinnamic acid	Caffeic acid	$C_9H_8O_4$	3.80
15	Fatty acid ester	Methyl stearate	$C_{19}H_{38}O_2$	11.18

16	Saturated fatty acid	n-Hexadecanoic acid	$C_{16}H_{32}O_2$	22.54
17	Phenol	Benzoic acid, 4-hydroxy-3,5-dimethoxy-	$C_9H_{10}O_5$	1.84
18	carbonhydrate	Sorbitol	$C_6H_{14}O_6$	2.41
19	Aldohexose	Glucose	$C_6H_{12}O_6$	6.74
20	Hydroxycinnamic acid	β-(4-Hydroxy-3-methoxyphenyl)propionic acid	$C_{10}H_{12}O_4$	10.15
21	Saturated fatty acid	Tetradecanoic acid	$C_{14}H_{28}O_2$	0.83
22	Phthalate ester	1,2-Benzenedicarboxylic acid, diheptyl ester	$C_{22}H_{34}O_4$	1.11

Table 7: Metabolite content of the methanolic extract of *Solanum nigrum*

Peak #	Metabolite Group	Compound Detected	Mol. Formula	Peak Area (%)
1	Phenol	Benzaldehyde, 4-hydroxy-	$C_7H_6O_2$	1.45
2	Trihydroxybenzene	1,3,5-Benzenetriol	$C_6H_6O_3$	2.39
3	Carboxylic acid	Salicylic acid	$C_7H_6O_3$	3.45
4	Phenol	Benzeneethanol, 4-hydroxy-	$C_8H_{10}O_2$	0.47
5	Pyrone	4H-Pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-methyl-	$C_6H_8O_4$	7.70
6	Phenol	Benzeneacetic acid, 4-hydroxy-	$C_8H_8O_3$	1.48
7	Carboxylic acid	Vanillic acid	$C_8H_8O_4$	3.87
8	Dihydroxybenzoic acid	Benzoic acid, 3,4-dihydroxy-	$C_7H_6O_4$	5.32
9	Alcohol	6-Octen-1-ol, 3,7-dimethyl-	$C_{10}H_{20}O$	1.92
10	Hydroxycinnamic acid	p-Coumaric acid	$C_9H_8O_3$	6.87
11	Hydroxycinnamic acid	2-Propenoic acid, 3-(3-hydroxyphenyl)-	$C_9H_8O_3$	5.57
12	Ketohexose	Fructose	$C_6H_{12}O_6$	2.36
13	Saturated fatty acid	n-Hexadecanoic acid	$C_{16}H_{32}O_2$	7.27
14	Hydroxycinnamic acid	Caffeic acid	$C_9H_8O_4$	5.35
15	Saturated fatty acid	Tetradecanoic acid	$C_{14}H_{28}O_2$	5.32
16	Sugar alcohol	Myo-Inositol	$C_6H_{12}O_6$	1.94
17	Phenol	Benzoic acid, 4-hydroxy-3,5-dimethoxy-	$C_9H_{10}O_5$	0.66
18	Hydroxycinnamic acid	trans-Ferulic acid	$C_{10}H_{10}O_4$	3.45
19	Aldohexose	Glucose	$C_6H_{12}O_6$	0.23
20	Hydroxycinnamic acid	β-(4-Hydroxy-3-methoxyphenyl)propionic acid	$C_{10}H_{12}O_4$	0.53
21	Fatty acid ester	Methyl tetradecanoate	$C_{15}H_{30}O_2$	4.74
22	Sugar alcohol	Sorbitol	$C_6H_{14}O_6$	2.45
23	Phenol	Benzaldehyde, 4-hydroxy-3,5-dimethoxy-	$C_9H_{10}O_4$	2.90

24	Aldehyde	Hexadecanal	$C_{16}H_{32}O$	7.88
25	Fatty acid ester	Methyl stearate	$C_{19}H_{38}O_2$	5.34
26	Fatty acid amide	13-Docosenamide, (Z)-	$C_{22}H_{43}NO$	7.89
27	Phthalate ester	1,2-Benzenedicarboxylic acid, diheptyl ester	$C_{22}H_{34}O_4$	1.06

Table 8: Metabolite content of the methanolic extract of *Amaranthus hydrides*

Peak #	Metabolite group	Compound Detected	Mol. Formula	Peak Area (%)
1	Phenolic compound	Benzaldehyde, 4-hydroxy-	$C_7H_6O_2$	1.64
2	Phenolic compound	1,3,5-Benzenetriol	$C_6H_6O_3$	2.44
3	Phenolic acid	Salicylic acid	$C_7H_6O_3$	1.64
4	Phenolic compound	Benzeneethanol, 4-hydroxy-	$C_8H_{10}O_2$	5.11
5	Pyranone derivative	4H-Pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-methyl-	$C_6H_8O_4$	0.39
6	Phenolic acid	Benzeneacetic acid, 4-hydroxy-	$C_8H_8O_3$	8.32
7	Phenolic acid	Vanillic acid	$C_8H_8O_4$	2.36
8	Dihydroxybenzoic acid	Benzoic acid, 3,4-dihydroxy-	$C_7H_6O_4$	0.97
9	Alcohol	6-Octen-1-ol, 3,7-dimethyl-	$C_{10}H_{20}O$	1.90
10	Phenolic acid	p-Coumaric acid	$C_9H_8O_3$	4.90
11	Cinnamic acid derivative	2-Propenoic acid, 3-(3-hydroxyphenyl)-	$C_9H_8O_3$	5.89
12	Fatty acid	n-Hexadecanoic acid	$C_{16}H_{32}O_2$	7.30
13	Monosaccharide	Fructose	$C_6H_{12}O_6$	2.90
14	Phenolic acid	Caffeic acid	$C_9H_8O_4$	5.78
15	Fatty acid	Tetradecanoic acid	$C_{14}H_{28}O_2$	6.46
16	Sugar alcohol	Myo-Inositol	$C_6H_{12}O_6$	4.87
17	Phenolic acid	Benzoic acid, 4-hydroxy-3,5-dimethoxy-	$C_9H_{10}O_5$	5.93
18	Phenolic acid	trans-Ferulic acid	$C_{10}H_{10}O_4$	2.01
19	Monosaccharide	Glucose	$C_6H_{12}O_6$	1.96
20	Phenolic acid derivative	β-(4-Hydroxy-3-methoxyphenyl)propionic acid	$C_{10}H_{12}O_4$	1.00
21	Fatty acid ester	Methyl tetradecanoate	$C_{15}H_{30}O_2$	0.73
22	Aldehyde	Hexadecanal	$C_{16}H_{32}O$	1.39
23	Phenolic compound	Benzaldehyde, 4-hydroxy-3,5-dimethoxy-	$C_9H_{10}O_4$	5.09
24	Sugar alcohol	Sorbitol	$C_6H_{14}O_6$	4.89
25	Fatty acid ester	Methyl stearate	$C_{19}H_{38}O_2$	5.88
26	Amide	13-Docosenamide, (Z)-	$C_{22}H_{43}NO$	1.02
27	Polyunsaturated fatty acid	9,12,15-Octadecatrienoic acid, (Z,Z,Z)-	$C_{18}H_{30}O_2$	6.15
28	Phthalate ester	1,2-Benzenedicarboxylic acid, diheptyl ester	$C_{22}H_{34}O_4$	1.03

Table 9: Metabolite content of the methanolic extract of *Launaea taraxacifolia*

Peak #	Metabolite Group	Compound Detected	Mol. Formula	Peak Area (%)
1	Phenolic compound	Benzaldehyde, 4-hydroxy-	$C_7H_6O_2$	2.17
2	Phenolic compound	1,3,5-Benzenetriol	$C_6H_6O_3$	1.04
3	Phenolic acid	Salicylic acid	$C_7H_6O_3$	2.52
4	Phenolic compound	Benzeneethanol, 4-hydroxy-	$C_8H_{10}O_2$	2.72
5	Pyranone derivative	4H-Pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-methyl-	$C_6H_8O_4$	2.80
6	Phenolic acid	Benzeneacetic acid, 4-hydroxy-	$C_8H_8O_3$	1.30
7	Phenolic acid	Vanillic acid	$C_8H_8O_4$	3.77
8	Dihydroxybenzoic acid	Benzoic acid, 3,4-dihydroxy-	$C_7H_6O_4$	3.86
9	Fatty acid	n-Hexadecanoic acid	$C_{16}H_{32}O_2$	11.87
10	Phenolic acid	p-Coumaric acid	$C_9H_8O_3$	2.45
11	Cinnamic acid derivative	2-Propenoic acid, 3-(3-hydroxyphenyl)-	$C_9H_8O_3$	6.06
12	Alcohol	6-Octen-1-ol, 3,7-dimethyl-	$C_{10}H_{20}O$	3.60
13	Monosaccharide	Fructose	$C_6H_{12}O_6$	2.53
14	Phenolic acid	Caffeic acid	$C_9H_8O_4$	5.03
15	Fatty acid	Tetradecanoic acid	$C_{14}H_{28}O_2$	6.57
16	Sugar alcohol	Myo-Inositol	$C_6H_{12}O_6$	1.90
17	Phenolic acid	Benzoic acid, 4-hydroxy-3,5-dimethoxy-	$C_9H_{10}O_5$	1.86
18	Phenolic acid	trans-Ferulic acid	$C_{10}H_{10}O_4$	4.98
19	Monosaccharide	Glucose	$C_6H_{12}O_6$	3.95
20	Phenolic acid derivative	β-(4-Hydroxy-3-methoxyphenyl)propionic acid	$C_{10}H_{12}O_4$	4.99
21	Fatty acid ester	Methyl tetradecanoate	$C_{15}H_{30}O_2$	4.41
22	Aldehyde	Hexadecanal	$C_{16}H_{32}O$	2.01
23	Phenolic compound	Benzaldehyde, 4-hydroxy-3,5-dimethoxy-	$C_9H_{10}O_4$	8.45
24	Sugar alcohol	Sorbitol	$C_6H_{14}O_6$	3.09
25	Fatty acid ester	Methyl stearate	$C_{19}H_{38}O_2$	3.15
26	Amide	13-Docosenamide, (Z)-	$C_{22}H_{43}NO$	1.09
27	Polyunsaturated fatty acid	9,12,15-Octadecatrienoic acid, (Z,Z,Z)-	$C_{18}H_{30}O_2$	1.08
28	Phthalate ester	1,2-Benzenedicarboxylic acid, diheptyl ester	$C_{22}H_{34}O_4$	0.82

Table 10: Metabolite content of the methanolic extract of *Telfairea occidentalis*

Peak #	Metabolite Group	Compound Detected	Mol. Formula	Peak Area (%)
1	Aldehyde	Benzaldehyde, 4-hydroxy-	$C_7H_6O_2$	0.62
2	Polyphenol	1,3,5-Benzenetriol	$C_6H_6O_3$	4.91
3	Phenolic acid	Salicylic acid	$C_7H_6O_3$	4.17
4	Alcohol	Benzeneethanol, 4-hydroxy-	$C_8H_{10}O_2$	6.49
5	Pyranone	4H-Pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-methyl-	$C_6H_8O_4$	0.64
6	Phenylacetic acid	Benzeneacetic acid, 4-hydroxy-	$C_8H_8O_3$	1.15
7	Phenolic acid	Vanillic acid	$C_8H_8O_4$	5.18
8	Phenolic acid	Benzoic acid, 3,4-dihydroxy-	$C_7H_6O_4$	5.65
9	Aldehyde	Benzaldehyde, 4-hydroxy-3,5-dimethoxy-	$C_9H_{10}O_4$	1.32
10	Phenylpropanoid	p-Coumaric acid	$C_9H_8O_3$	3.94
11	Cinnamic acid	2-Propenoic acid, 3-(3-hydroxyphenyl)-	$C_9H_8O_3$	5.93
12	Alcohol	6-Octen-1-ol, 3,7-dimethyl-	$C_{10}H_{20}O$	2.87

13	Monosaccharide	Fructose	$C_6H_{12}O_6$	3.43
14	Phenylpropenoic acid	Caffeic acid	$C_9H_8O_4$	5.44
15	Fatty acid	Tetradecanoic acid	$C_{14}H_{28}O_2$	3.15
16	Polyol	Myo-Inositol	$C_6H_{12}O_6$	3.43
17	Phenolic acid	Benzoic acid, 4-hydroxy-3,5-dimethoxy-	$C_9H_{10}O_5$	4.03
18	Phenylpropenoic acid	trans-Ferulic acid	$C_{10}H_{10}O_4$	5.47
19	Monosaccharide	Glucose	$C_6H_{12}O_6$	3.73
20	Phenylpropionic acid	β-(4-Hydroxy-3-methoxyphenyl)propionic acid	$C_{10}H_{12}O_4$	1.48
21	Fatty acid ester	Methyl tetradecanoate	$C_{15}H_{30}O_2$	0.90
22	Aldehyde	Hexadecanal	$C_{16}H_{32}O$	0.57
23	Polyol	Sorbitol	$C_6H_{14}O_6$	0.84
24	Fatty acid	n-Hexadecanoic acid	$C_{16}H_{32}O_2$	5.33
25	Fatty acid ester	Methyl stearate	$C_{19}H_{38}O_2$	1.81
26	Phenylpropanoid	3,5-Dimethoxy-4-hydroxycinnamic acid	$C_{11}H_{12}O_5$	3.44
27	Fatty acid	9,12,15-Octadecatrienoic acid, (Z,Z,Z)-	$C_{18}H_{30}O_2$	4.01
28	Flavonoid	Quercetin	$C_{15}H_{10}O_7$	1.67
29	Polyphenol	Ellagic acid	$C_{14}H_6O_8$	2.84
30	Amide	13-Docosenamide, (Z)-	$C_{22}H_{43}NO$	1.06
31	Disaccharide	Sucrose	$C_{12}H_{22}O_{11}$	3.62
32	Phthalate	1,2-Benzenedicarboxylic acid, diheptyl ester	$C_{22}H_{34}O_4$	0.77