South African Journal of Botany, Volume 181, June 2025, pp. 162-171
DOI: 10.1016/j.sajb.2025.04.023

Comparative Profiling of Bioactive Compounds and Antioxidant Activity of Extracts from Selected Medicinal Plants: Implications for Mitigating Obesity-related Inflammation

Mlungisi F. Mngoma [a], Lembe S. Magwaza [b,c], Asanda Mditshwa [a*], Samson Z. Tesfay [a], Blessing N Mkhwanazi [d], Mbukeni A Nkomo [e]

[a] Discipline of Horticultural Science, School of Agricultural, Earth and Environmental Sciences, University of KwaZulu-Natal, Private Bag X01, Scottsville, 3209, Pietermaritzburg, South Africa

[b] Plant Science Laboratory, Cranfield University, Cranfield MK43 AL, UK

[c] Department of Food Systems and Development, Faculty of Natural and Agricultural Sciences, University of Free State, Bloemfontein, South Africa

[d] Discipline of Dietetics and Nutrition, School of Agricultural, Earth and Environmental Sciences, University of KwaZulu-Natal, Private Bag X01, Scottsville, 3209, Pietermaritzburg, South Africa

[e] School of Life Science, University of KwaZulu-Natal, Westville Campus, Durban 4000

*Correspondence: mditshwaa@ukzn.ac.za

Abstract

Obesity is a metabolic disorder, contributing to various health complications, including diabetes, hypertension, and cardiovascular dysfunction. Increased use of plant extracts to reduce obesity risk reflects consumer preference for natural remedies and scientific validation for their safety and efficacy. This study profiled bioactive compounds in methanolic extracts from the leaves and roots of *Merwilla plumbea* (Lindl.) Speta, *Hypoxis hemerocallidea* Fisch, *Eucomis autumnalis* (Mill.) Chitt, and *Pentanisia prunelloides* (Klotzsch) Walp. The objective was to explore and compare the medicinal properties of distinct plant parts for their potential to mitigate obesity-induced

inflammation. *P. prunelloides* leaves and roots had higher concentrations of phenolics (123.92 mg/mL and 110.01 mg/mL) and flavonoids (44.4 mg/mL and 55.05 mg/mL), respectively. Gallotannins were significantly higher in *H. hemerocallidea* roots (5.19 mg/mL) while proanthocyanidins were predominantly found in *P. prunelloides* roots (35.77 mg/mL). The antioxidant activity was assessed by ferric reducing antioxidant potential (FRAP) and DPPH radical scavenging activity (RSA) assays. *P. prunelloides* roots had higher FRAP (2.97 mg/mL) and moderate DPPH (RSA) (52.89%) while *M. plumbea* roots had the highest DPPH RSA (80.86%) and lower FRAP (2.25 mg/mL). *E. autumnalis* roots and leaves showed FRAP values of 2.78 and 2.13 mg/mL, and DPPH RSA of 80.72 and 74.54%, respectively. The results revealed that all plants investigated had considerable amounts of bioactive compounds with *P. prunelloides* showing the highest concentration, highlighting its potential for further pharmaceutical and nutraceutical exploration. Further research validating the bioactivity of key compounds in vivo, exploring seasonal variations, and assessing optimal harvesting practices is paramount for the sustainable utilization of these medicinal plants.

Keywords: adipose, antioxidants, inflammation, inhibition, phytochemicals.

1. Introduction

Obesity has become a pandemic, presenting a burgeoning challenge due to its intricate and chronic nature, influenced by the contribution of mymarid factors. This condition involves disruptions in multiple physiological aspects, such as imbalances in energy, dysregulation of central appetite, hormone changes, and gut microbiome composition (Breton et al., 2022). Recent global data reported by the World Health Organization (WHO) revealed that more than 1 billion individuals, comprising 650 million adults, 340 million adolescents, and 39 million children, are affected by obesity (Aborode et al., 2023). Survey data from 2016 underscores the severity of the issue, indicating that 68% of women and 33% of men in South Africa were categorized as obese, surpassing prevalence rates in the sub-Saharan region (NDoH and SAMRC, 2017, Smith et al., 2023).

Obesity is characterized by adipogenesis, a process encompassing hyperplasia and hypertrophy as body adaptive response mechanisms to excess consumption of calories (Rosen and Spiegelman,

2014). Obesity is also linked with low-grade inflammation, marked by the infiltration of macrophages and the secretion of pro-inflammatory cytokines, such as interleukin 6 (IL-6), interleukin-1β (IL-1β), and tumour necrosis factor (TNF-α) (Chen et al., 2018). Prolonged activation of inflammatory cytokines inhibits anti-inflammatory response, resulting in oxidative stress, a pathological state characterized by a dysregulation between the generation of reactive oxygen species (ROS) and the body's antioxidant defence systems. This oxidative imbalance exacerbates insulin resistance, the development of metabolic disorders, and increases the risk of conditions such as diabetes mellitus, heart failure, dyslipidemia, and fatty liver (Leyva-Jiménez et al., 2020, Lim et al., 2013).

Antioxidants play an important role in balancing ROS, reducing lipid peroxidation, and modulating inflammatory signaling pathways (Zielinska-Blizniewska et al., 2019). Plant-derived antioxidants, particularly polyphenolic compounds have gained increasing attention owing to their capacity to scavenge free radicals, modulate adipogenesis, and enhance metabolic homeostasis. Among the most studied plant-derived antioxidants, several bioactive compounds have demonstrated anti-inflammatory and antioxidant effects in obesity management, including, chlorogenic acid which inhibits pancreatic lipase by acting directly on its active site thereby reducing dietary fat absorption (Podsędek et al., 2020). Catechin and proanthocyanidin reduce adipogenesis by downregulating the expression of transcription factors, peroxisome proliferator-activated receptor gamma (PPARγ), and CCAAT/enhancer-binding protein alpha (C/EBPα) which are essential for the differentiation of preadipocytes into mature adipocytes (Kim et al., 2024, Nugrahini et al., 2024). Quercetin also exerts an anti-obesity effect by inhibiting sterol regulatory element-binding protein 1c (SREBP-1c) involved in the synthesis of fatty acids in the liver (Oliveira et al., 2022). Gallotannins block the active site of pancreatic lipase to reduce fat absorption and reduce adipogenesis by decreasing the expression of PPARγ and C/EBPα (Singh et al., 2020).

Traditional medicinal plants have been extensively examined for their polyphenolic constituents and antioxidant potential, particularly in alleviating oxidative stress and inflammation. Several plants including, *Merwilla plumbea*, *Hypoxis hemerocallidea*, *Eucomis autumnalis*, and *Pentanisia prunelloides*, have been utilized as natural remedies for their potential as antioxidant,

metabolic regulatory properties and anti-inflammatory (Alaribe et al., 2018, Matyanga et al., 2020, Mpofu et al., 2014). However, despite their traditional applications, limited research has been conducted to systematically profile their bioactive compounds and antioxidant activities in the context of obesity-induced inflammation. Additionally, it remains unclear which plant parts harbour high concentrations of bioactive compounds, making it essential to investigate their specific phytochemical composition and functional potential. This study aims to address these gaps by profiling the phytochemical and antioxidant activities of *M. plumbea*, *H. hemerocallidea*, *E. autumnalis,* and *P. prunelloides*, with a focus on their potential therapeutic benefits against obesity-induced inflammation.

2. Materials and methods

2.1 Plant material

The plant samples of *M. plumbea, H. hemerocallidea, E. autumnalis,* and *P. prunelloides* were collected from the University of KwaZulu-Natal Botanical Garden, Pietermaritzburg, South Africa (29°37'28" S30°24'13" E). The plant species was identified by a qualified horticulturist Mrs Alison Young. A voucher specimen of the plant was deposited at the Bews herbarium, School of Life Sciences, University of KwaZulu-Natal, Pietermaritzburg, South Africa The plant samples were separated into roots and leaves and rinsed with water to remove debris. The samples were thereafter oven-dried (Incotherm, Laboratory Consumables Pty, South Africa) at 60 °C for 3 days as described by Ncube et al. (2011).

2.2 Experimental design

The experiment was conducted using a factorial randomised complete design (RCD) to evaluate the effects of plant species and parts on the bioactive compound composition and antioxidant activity of medicinal plant extracts. The study included four plant species namely, *M. plumbea, H. hemerocallidea, E. autumnalis,* and *P. prunelloides.* Each plant species was evaluated based on two plant parts (leaves and roots), leading to a factorial structure (4 plant species and 2 plant parts). Each treatment (species × plant part) was replicated three times, resulting in 24 experimental units (4 species × 2 plant parts × 3 replicates = 24n).

2.3 Preparation of plant extracts

Dried plants parts of *M. plumbea, H. hemerocallidea, E. autumnalis,* and *P. prunelloides* (leaves and root) material were ground into a fine powder using an electric warring. A 2 g of powdered plant material was extracted separately in 40 mL of 80% (v/v) methanol and distilled water as described by Yildiz-Ozturk et al. (2015). The setup was placed on a Labcorn Platform shaker (Laboratory consumables, Durban, South Africa) at 150 rpm at 25 °C for 24 h. The plant extracts were centrifuged at 3000 rpm for 5 min and filtered through Whatman No.1 filter paper (Whatman, UK) to obtain a homogenous mixture. Filtrates were stored in a refrigerator at 4 °C until use. All extractions were performed in triplicate to ensure statistical reliability of the results.

2.4 Determination and quantification of total phenolic compounds

The concentration of total phenolics was determined using the Folin Ciocalteu (Folin C) assay as described by Joint (2000). A 50 µL of plant extract was transferred into a test tube, followed by adding 950 µL of distilled water, 500 µL of 1 N Folin C phenol reagent, and 2.5 mL of 2% (w/v) sodium carbonate. A blank containing 80% (v/v) aqueous methanol was prepared. The mixtures were incubated at room temperature for 40 min. The absorbance was read at 725 nm using a UV–vis spectrophotometer (Thermoscientific, Multiskan Sky, Vantaa, Finland). The total phenolic concentrations were expressed as gallic acid equivalents at a concentration from 2-150 mg/mL ($y = 0.0151x + 0.0519$: $R^2 = 98$). All measurements were performed in triplicate.

2.5 Extraction and quantification of flavonoids

The 50 µL plant extract was added to 1 mL methanol in a test tube followed by adding 2.5 mL methanolic–1 N hydrochloric acid (95:5, v/v) and 2.5 mL vanillin reagent (1 g/100 mL acetic acid) (Csepregi et al., 2013). The blank containing 80% (v/v) methanol was prepared. The mixture was incubated for 20 min at room temperature, absorbance was read at 500 nm using a UV-vis spectrophotometer (Thermoscientific, Multiskan Sky, Vantaa, Finland). The flavonoid concentration was quantified from the standard curve ranging from 18 to 150 mg/mL ($y = 0.0005x - 0.0057$: $R^2 = 96$) expressed as catechin equivalents (Hagerman, 2002). All measurements were conducted in triplicate to ensure reproducibility and statistical reliability of the results.

2.6 Extraction and quantification of gallotannins

Plant extracts (50 µL) in a test tube were added up to 1 mL with distilled water and followed by 100 µL of 0.4 N sulphuric acid and 600 µL of 0.67% (w/v) rhodanine methanolic solution was added to the diluted extracts (Moyo et al., 2013). After 5 min, 200 µL of 0.5 N potassium hydroxide was added followed by 4 mL distilled water after a further 2.5 min. The mixtures were left for an additional 15 min at room temperature, after which the absorbance at 520 nm was read using a UV–vis spectrophotometer (Thermoscientific, Multiskan Sky, Vantaa, Finland) against a blank that contained methanol instead of plant extract. Gallotannin concentration was interpolated from the 1.2 – 75mg/mL standard curve (y = 0.0226x - 0.0073: R^2 = 99) and expressed as gallic acid equivalents Joint (2000). Each sample was analysed in triplicate, ensuring the accuracy and repeatability of the results.

2.7 Determination of proanthocyanidins

The 1.2 mL of butanol–Hydrochloric acid reagent (95:5, v/v) was transferred to a test tube containing 200 µL of each plant extract sample and followed by 40 µL ferric reagent (2% ferric ammonium sulphate in 2 N Hydrochloric acid) (Ghuman et al., 2016). The test combination was vortexed (Lab dancer V, Cole Parmer, Germany) and placed in a boiling water bath for 1 h. The absorbance was read at 580 nm using a UV–vis spectrophotometer (Thermoscientific, Multiskan Sky, Vantaa, Finland). All measurements were made in triplicate. A blank containing 80% aqueous methanol was also prepared but without heating. Condensed tannin (%) was calculated as leucocyanidin equivalents using Eq. 1, developed by Porter et al. (1985).

$$Condensed\ tannin\ (\%) = (A580\ nm \times 78.26 \times Dilution\ factor)/(\%\ dry\ matter) \quad 1$$

This formula assumes that the effective $E\ 1^{\%,\ 1\ cm,\ 580\ nm}$ of leucocyanidin is 460 (Al-Alimi et al., 2017). The dilution factor was 1 since 80% methanol was not added to prevent the absorbance from exceeding 0.6. If absorbance exceeds 0.6, the extraction solvent dilutes it to allow the spectrophotometer to read the sample.

2.8 Determination of antioxidant activity using ferric-reducing antioxidant potential (FRAP)

The FRAP assay was measured using a modified method described by Rabeta and Faraniza (2013). Briefly, 90 µL of plant extract was transferred into a tube and followed by 40 µL of potassium phosphate buffer having a pH of 7.2. Potassium ferricyanide (40 µL) containing 1% (w/v) was added, covered with aluminium foil, and incubated at 50 °C for 20 min. After incubation, 120 µL of distilled water was added, followed by 40 µL trichloroacetic acid (10 % (w/v)) and 30 µL of 0.1 % w/v $FeCl_3$ (prepared in dark room). The aqueous methanol (80%) was used as a blank. The mixture was allowed to stand at room temperature for 30 min. The absorbance was measured at 593 nm using a UV–vis spectrophotometer (Thermoscientific, Multiskan Sky, Vantaa, Finland, Vantaa, Finland). The standard calibration curve was constructed as described by Gohari et al. (2011) using $FeSO_4$, $7H_2O$ at concentrations from 0.78 – 10mg.mL^{-1} ($y = 0.7401x + 0.0405$: R^2 = 99). Analyses were made in triplicate.

2.9 The antioxidant activity in scavenging DPPH

Free radical scavenging activity of 2,2-diphenyl-1-picryhydrazyl (DPPH) was determined using a modified method described by Gulcin and Alwasel (2023), with all tests performed in triplicate. Briefly, 20 µL of each plant extract was added in a test tube containing 130 µL of methanol and followed by 1500 µL DPPH solution mixture. The reactions were performed under a dim light and incubated at room temperature for 30 min. The absorbance was measured at 517 nm using a UV–vis spectrophotometer (Thermoscientific, Multiskan Sky, Vantaa, Finland). Free radical scavenging activity (RSA) was calculated using Eq. 2.

$$RSA\% = (AD - AE/AD) \times 100 \qquad 2$$

Where RSA% was the inhibition percentage of free radical scavenging activity, AD was a control absorbance where the solvent was mixed with DPPH radical solution instead of plant extract and AE was the absorbance of the tested sample.

205 **2.10 Profiling of phenolic compounds**

206 **2.10.1 Sample preparation**

207 A 0.5 g dry powdered plant material was extracted with 10 mL of 50% methanol/1 % formic acid,
208 concentrated by sonication for 1 h. The solution was centrifuged for 10 min at a speed of 3000
209 rpm, and the supernatant was diluted 5-fold with 50% methanol/0.1 % formic acid and transferred
210 to a glass vial for analysis. All extractions were performed in triplicate.

211 **2.10.2 Liquid chromatography-mass spectrometry (LCMS) analysis**

212 The analysis was conducted using a high-resolution Waters Cyclic Quadrupole time-of-flight
213 (qTOF) mass spectrometer (MS) connected to a Waters Acquity ultra-performance liquid
214 chromatograph (UPLC) (Waters, Milford, MA, USA). The column eluate first traversed a
215 Photodiode Array (PDA) detector before reaching the mass spectrometer, enabling simultaneous
216 collection of UV and MS spectra. The positive mode of electrospray ionization utilized a cone
217 voltage of 15 V, desolvation temperature of 275 °C, desolvation gas flow rate set at 650 L/h, and
218 the remaining MS parameters were fine-tuned for optimal resolution and sensitivity. Data were
219 detected by scanning from mass-to-charge ion (m/z) of 100 to 1500 in a resolution mode as well
220 as in mass spectrometry elevated energy (MSE) mode. Two channels of MS data were acquired in
221 MSE mode, one at a low collision energy (4 V) and the second one at 40 −100 V to obtain
222 fragmentation data. For precise mass determination, leucine enkaphalin was used as lock mass
223 (reference mass) and the instrument was calibrated with sodium formate. Separation was obtained
224 on a Waters HSS T3, 2.1 × 150 mm, 1.7 µm column. The 0.5 µL of 0.1% formic acid (solvent A)
225 was injected and followed by 0.5 µL acetonitrile containing 0.1% formic acid as solvent B. The
226 gradient was initiated at 100% solvent A for 1 min and reduced to 28% B over 11 min in a linear
227 way. It then increased to 40% B over 50 s and a wash step of 1.5 min at 100% B, followed by re-
228 equilibration to initial conditions for 2 min. The flow rate was 0.3 mL/min, and the column
229 temperature was kept at 60 °C. Compounds were quantified relatively against a calibration curve
230 established by injecting a range of rutin standards from 0.2 to 5 mg/L rutin.

2.11 Data analysis

All data collected from different plant species and parts were replicated three times and analysed using a two-way ANOVA in GenStat [23rd Edition (VSN International, Hemel Hempstead, UK)]. Mean values recorded were separated using Duncan's multiple range test at a 5% significance level. The Standard Error (SE) of the mean was calculated based on replication to represent the precision of the mean values. Multivariate analysis and principal component (PCA) were executed using MetaboAnalyst software version 6 (R package optiLCMS, 2024).

3. Results and discussion

3.1 Phytochemical analysis

3.1.2 Phenolic content

The analyses of phenolics, flavonoids, gallotannins, and proanthocyanidins revealed significant differences ($p < 0.001$) among the plant species and parts. Phenolic concentrations were highest in *P. prunelloides* leaves (123.92 mg/mL) and roots (110.01 mg/mL), followed by *H. hemerocallidea* roots (89.21 mg/mL), with the lowest levels observed in *E. autumnalis* leaves (11.29 mg/mL) (Fig. 1A). The biosynthesis of phenolics is stimulated by the gene encoding for phenylalanine ammonia-lyase (PAL) enzyme through shikimate and phenylpropanoid pathways (Deng and Lu, 2017). The type and expression level of the PAL encoding genes differs with plant species. The increase in the PAL enzymes may be attributed to higher phenolic concentration in these plant species. The observed results showed significant differences ($p < 0.001$) between leaves and roots of the same species where *P. prunelloides* exhibited 11% higher phenolic concentration in leaves compared to roots. Similarly, *M. plumbea* showed a 49% increase in phenolic concentration in leaves than roots. *E. autumnalis* also showed 33% higher phenolic in plant leaves than roots. The leaves are primarily essential for photosynthesis, where light energy is converted into chemical energy. During this process, a wide range of metabolites such as phenolic compounds are produced which are essential for protecting the plant against UV radiation, pathogens, and herbivores (Chowdhary et al., 2021). It could be argued that the higher phenolic concentration in the leaves of these plants was due to the direct exposure of leaves to sunlight which necessitated their production to protect the plant from UV radiation. Contrarily, *Hypoxis hemerocallidea* had a 63% higher phenolic content in roots

than the leaves, which we hypothesised to be a plant strategy to protect storage organs from oxidative damage, pathogens, and other stresses during dormancy periods.

3.1.2 Flavonoid content

The higher flavonoid concentration was demonstrated by *P. prunelloides* roots (55.05 mg/mL) and leaves (44.37 mg/mL) and *H. hemerocallidea* roots (44.6 mg/mL). A lower flavonoid was observed in *E. autumnalis* (10.02 mg/mL) (Fig. 1B). The biosynthesis of flavonoid in plants is associated with phenylpropanoid pathways through the synthesis of chalcone synthase (CHS), chalcone isomerase (CHI), and flavanone 3-hydroxylase (F3H) (Kausar et al., 2020). The regulation of these enzymes can result in differences in flavonoid concentration. Higher flavonoid concentration in these plants may result from increased activities of these enzymes, conversely, plant species that showed lower flavonoids explained lower activity levels of enzymes. Among plant parts, *H. hemerocallidea* showed 56% higher flavonoid concentration in the roots than in leaves, whereas other plant species exhibited no significant difference between plant parts. The essential biochemical pathways for flavonoid biosynthesis in roots and leaves are the same, however, regulation of these pathways can vary due to developmental cues, tissue-specific metabolic needs, and environmental factors (Shi et al., 2024). For example, roots are the storage organ that stores nutrients and energy for plant survival during adverse conditions, thus, flavonoids possess antioxidant properties to protect the stored nutrients from microbial attack, oxidation, and other stresses.

3.1.3 Gallotannin content

The quantification of gallotannin exhibited significant differences ($p < 0.001$) among various plant species. *H. hemerocallidea* roots and leaves and *P. prunelloides* roots had higher gallotannin concentrations (5.19 mg/mL, 4.27 mg/mL, and 4.07 mg/mL), respectively. The least gallotannin was observed in *M. plumbea* roots (2.18 mg/mL). Similarly, Ncube et al. (2011) reported high gallotanins in *H. hemerocallidea* than *M. plumbea.* Gallotannins are hydrolyzable tannins derived from gallic acid, which is produced through the shikimate pathway. This pathway involves the conversion of glucose and other precursors into galloyl glucose and consequently into gallotannins

via the action of the enzyme tannin acyl hydrolase (Sharma et al., 2017). Variations in gallotannin concentration of these plant species were attributed by the activity of these enzymes. On the other hand, differences in the genetics of these plant species also contribute to the variation of secondary metabolites biosynthesis. Comparisons on plant parts showed significant variation, where *H. hemerocallidea* (10%) *and P. prunelloides* (6%) had higher gallotannins in the roots than leaves (Fig. 1C). On the other hand, *M. plumbea* (15%) and *E. autumnalis* (7%) exhibited higher gallotannin content in the leaves than in the roots. Variation in gallotannin distribution between roots and leaves among these plant species highlights their distinct strategies to mitigate environmental stress such as UV radiation, herbivory, pathogen attack, and oxidative damage (Alamgir, 2018).

3.1.4 Proanthocyanidins content

Proanthocyanidins are an essential class of structurally complex secondary metabolites and exist naturally as phenolic compounds (Jiang et al., 2015). The results showed a significant difference ($p \leq 0.001$) in proanthocyanidins among the tested plant species (Fig. 1D). A higher concentration of proanthocyanidins was detected in *Pentanisia prunelloides* roots (36%) and leaves (26%) while lower proanthocyanidins exhibited by *Eucomis autumnalis* (0.4%). Proanthocyanidins are oligomers and polymers composed of elementary flavan-3-ol units particularly (−)-epicatechin and (+)-catechin. This compound synthesis from L-phenylalanine through phenylpropanoid and flavonoid pathways (Mora et al., 2022). The enzymes involved in this process include phenylalanine ammonia-lyase (PAL), chalcone synthase (CHS), dihydroflavonol 4-reductase (DFR), and leucoanthocyanidin reductase (LAR) (Deng and Lu, 2017). The activity and gene encoding expression of these enzymes can be different among various plant species. For example, higher activity of DFR and LAR in *P. prunelloides* could explain the increased proanthocyanidin concentration. Comparisons of plant parts revealed that *Pentanisia prunelloides* and *Hypoxis hemerocallidea* had higher proanthocyanidins in the roots than in the leaves. In contrast, *Merwilla plumbea* and *Eucomis autumnalis* showed higher levels of proanthocyanidins in leaves than in roots. The current findings were in agreement with Ncube et al. (2011) who found higher concentrations of proanthocyanidins in *Hypoxis hemerocallidea* roots than in leaves whereas *Merwilla plumbea* exhibited higher concentrations in leaves than roots. Specific transcription factors such as myeloblastosis (MYB), basic helix-loop-helix (bHLH), and WD40 repeat (WD40)

which modulate flavonoid biosynthetic pathways might be differentially expressed in roots and leaves, resulting in the specific accumulation of proanthocyanidins in certain tissues (Pratyusha and Sarada, 2022).

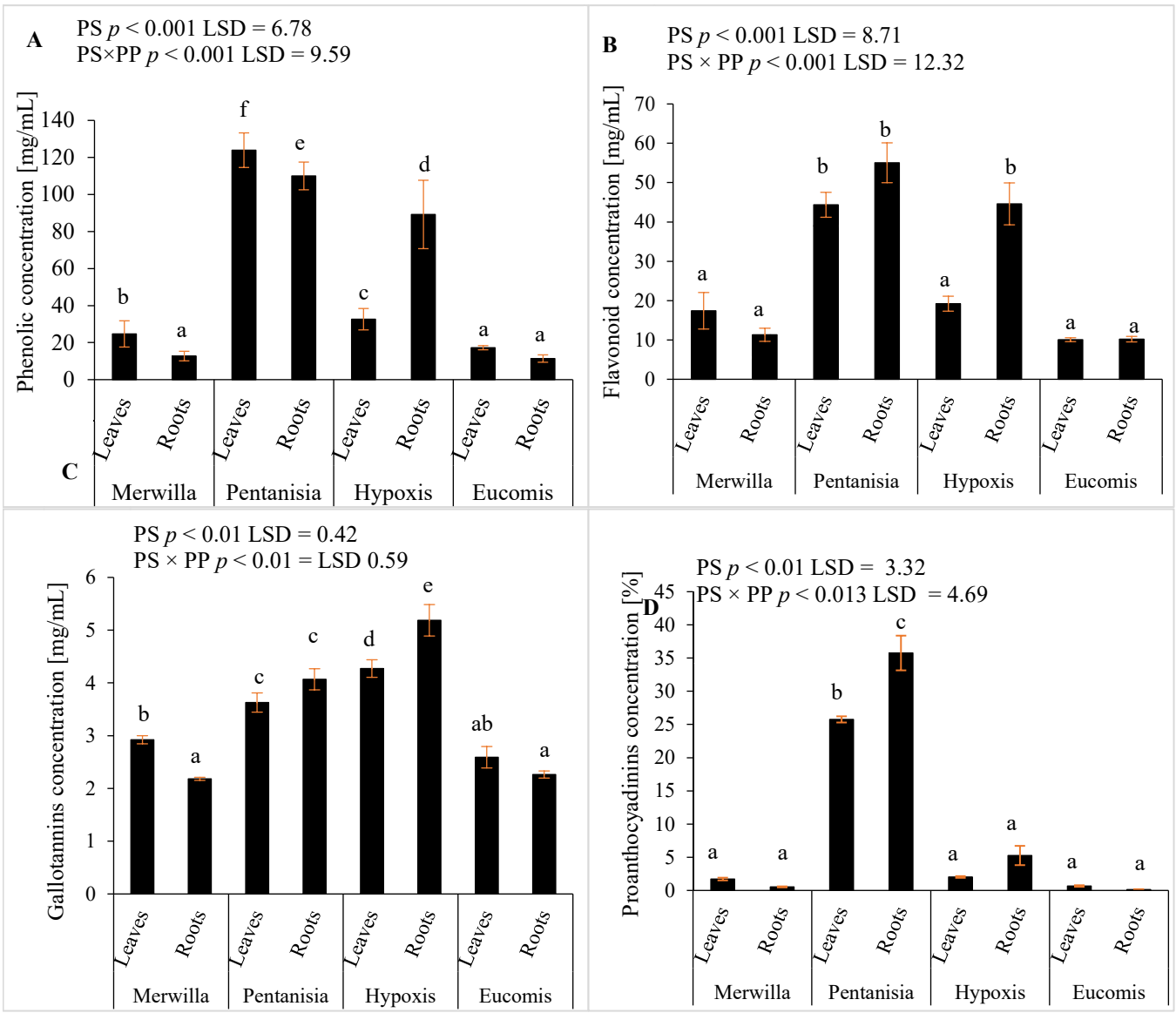

Fig. 1. The phytochemical concentration of different parts of *Merwilla plumbea, Pentanisia prunelloides*, *Hypoxis hemerocallidea,* and *Eucomis autumnalis.* The values are presented as means ± SEM (n = 3) and LSD (n=24), the significant difference at the $p < 0.001$ level was

observed among various plant species and their plant parts (leaves and roots), means of treatments sharing the same letter (s) are not significantly different at 5% level of significance. Abbreviations: PS, plant species; PP, plant part. LSD, least significant difference.

3.2 Antioxidant activity

3.2.1 Ferric reducing antioxidant potential assay and DPPH radical oxygen scavenger

FRAP assay measures the capability of plant constituents to reduce ferric (Fe^{3+}) ions to ferrous (Fe^{2+}) while DPPH assay quantifies the ability of compounds to scavenge free radicals by donating hydrogen atoms (Bisht et al., 2024, Gulcin, 2020, Gulcin et al., 2019). The roots of *P prunelloides* showed a FRAP value of 2.97 mg/mL and a DPPH RSA quantified at 52.89%. In contrast, its leaves demonstrated a FRAP of 2.60 mg/mL and a notable DPPH RSA of 35.25% (Table. 1). Similarly, Mbhele (2021) found that *Pentanisia prunelloides* extracted with 50% methanol showed good reducing activity of FRAP. *M. plumbea* roots had a FRAP value of 2.25 mg/mL and a higher DPPH RSA of 80.86%, whereas the leaves revealed a FRAP of 1.66 mg/mL and a DPPH RSA of 66.25%. The antioxidant enzymatic systems such as superoxide dismutase, peroxidases, and catalase may vary between roots and leaves, contributing to variations in the antioxidant potential (Kasote et al., 2015). The roots and leaves of *H. hemerocallidea* recorded FRAP values of 1.85 and 1.93 mg/mL, respectively, with corresponding DPPH RSA values of 46.31% and 61.18%. Both roots and leaves showed similar reducing power as reflected by FRAP values, however, higher DPPH in leaves underscores their increased capacity to scavenge free radicals. This variation may be an adaptive response to the changing environmental conditions faced by leaves and roots. In this quest, leaves may require stronger protection against oxidative damage due to their exposure to sunlight and atmosphere. *E. autumnalis* roots and leaves respectively exhibited FRAP values of 2.78 mg/ml and 2.13 mg/ml with corresponding DPPH RSA of 80.72% and 74.54%. Elevated FRAP and DPPH in *E. autumnalis* roots indicated that roots possess strong mechanisms to suppress oxidative stress due to highly effective antioxidant compounds or stress hormones such as abscisic acid. However, this trend was not consistent across all plant species, suggesting, that various species have different antioxidant profiles and activities, depending on their specific compound's composition.

Table 1: The antioxidant activity [means ± SEM (n = 3)] in various plant parts of *Merwilla plumbea, Pentanisia prunelloides, Hypoxis hemerocallidea,* and *Eucomis autumnalis.*

Plant Species	Plant Part	FRAP (mg.mL)	DPPH (RSA%)
		Mean ± SE	Mean ± SE
P. prunelloides	Roots	2.97 ^{e} ± 0.37	52.89 c ± 7.39
	Leaves	2.60 ^{d} ± 0.23	35.25 ^{a} ± 15.53
M. plumbea	Roots	2.25 ^{c} ± 0.72	80.86 ^{e} ± 4.27
	Leaves	1.66 ^{a} ± 0.10	66.25 ^{d} ± 8.24
H. hemerocallidea	Roots	1.85 ^{ab} ± 0.10	46.31 ^{b} ± 5.56
	Leaves	1.93 ^{abc} ± 0.15	61.18 ^{d} ± 6.07
E. autumnalis	Roots	2.78 ^{de} ± 0.70	80.72 ^{e} ± 0.71
	Leaves	2.13 ^{bc} ± 0.40	74.54 ^{e} ± 4.5
LSD		0.31	6.34
P-value		<.001	<.001

Abbreviations: FRAP, ferric reducing antioxidant potential assay; DPPH, 2, 2-diphenyl-1-picryhydrazyl; ± SE, minimum and maximum standard error; LSD, least significant difference. The values are presented as means (n = 3) and LSD (n=24), the significant difference at the $p <$ 0.001 level was observed among various plant species and their plant parts (leaves and roots), means of treatments sharing the same letter (s) are not significantly different at 5% level of significance.

3.3 Multivariate Analysis of Phytochemical Composition

3.3.1 Principal components

The principal component analysis (PCA) was used to visualize the relationship between phenolics flavonoid, gallotannin, proanthocyanidins, FRAP, and DPPH under different plant species (Fig. 2). PC1 explains the most variation in the data, with contributions from compounds that are aligned along the horizontal axis whereas PC2 present the next highest amount of variation, showing differences that are aligned along the vertical axis. The factor with higher loading scores means a tighter relationship with the same principal component. The PCA results revealed two significant

components PC1(90.1%) and PC2 (5.1%) that accumulated to 95.2 % of the total variance of the investigated parameters. The sample position showed *H. hemerocallidea* roots positively correlated with PC1 and PC2 indicating association with compounds that positively contribute to both components particularly, proanthocyanidins, phenolics, and flavonoids. *P. prunelloides* roots and leaves were positioned on the far right of PC1 suggesting a strong correlation to proanthocyanidins and phenolics. *E. autumnalis* roots located on the highest point of PC2 indicating a strong association with compounds positively contributed to loading PC2. *M. plumbea* roots and leaves are positioned near the center and slightly on the negative score of PC1 and PC2 representing alignment with gallotannins and moderate levels of flavonoids and phenolics. *E. autumnalis* leaves and *H. hemerocallidea* leaves are negatively associated with PC1 and PC2 highlighting the alignment with FRAP and DPPH but lower compounds that define positive PC1 and PC2.

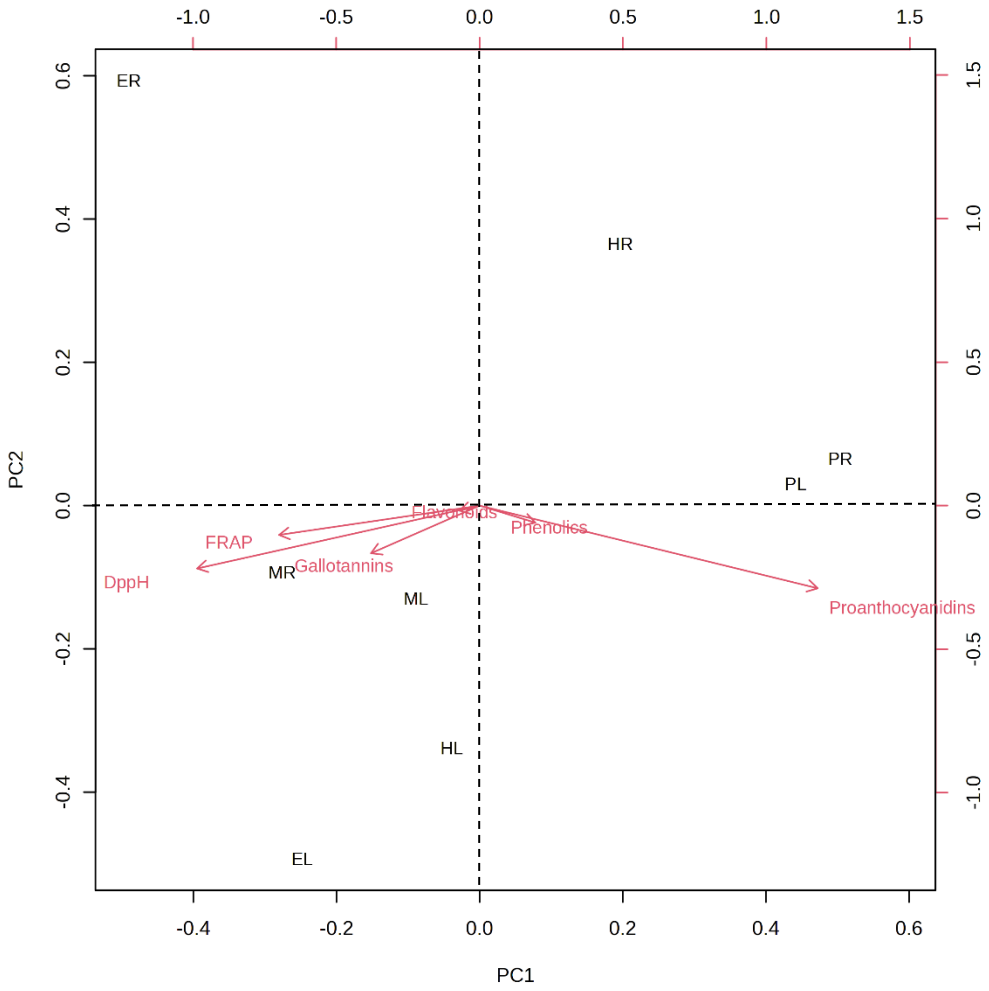

Fig. 2. Principal component analysis chart for two principal components showing the relationship between different plant parts of *Merwilla plumbea, Pentanisia prunelloides*, *Hypoxis hemerocallidea,* and *Eucomis autumnalis,* and their compounds were analysed in triplicate. Abbreviations: PCA, principal components; HL, *Hypoxis hemerocallidea* leaves; HR, *Hypoxis hemerocallidea* roots; PL, *Pentanisia prunelloides* leaves; PR*, Pentanisia prunelloides* roots; EL, *Eucomis autumnalis* leaves; ER*, Eucomis autumnalis* roots; ML, *Merwilla plumbea* leaves; MR, *Merwilla plumbea* roots.

3.4 LC-MS/MS identification of polyphenolic compounds

3.4.1 overview of identified compounds

Based on the untargeted LCMS analysis, 1007 compounds were discovered across all four plant species. Out of 1007 compounds, 776 were assigned names while 231 remained unclassified. There were 27 major compounds identified from different plant extracts that showed potential to be used as anti-obesity and anti-inflammatory (Table 2). The selection criteria were based on the literature reported on the biological activities of compounds including, their ability to inhibit lipid metabolic enzymes and inflammatory pathways. These compounds were classified into 6 categories including phenolic acids, flavonoids, terpenoids, saponins, fatty acids, and other polyphenols.

3.4.2 Phenolic acids

The three phenolic acids observed were tentatively characterized through MS/MS fragmentation. The compound gentesic acid 5-O-glucoside (*m/z* 315.07) exhibited daughter ions at *m/z* 153 and *m/z* 109 by the loss of the glucoside moiety (162 Da) and carboxyl (44 Da), respectively (Mashitoa et al., 2021). Similarly, Karageçili et al. (2023a), Karagecili et al. (2023b) reported daughter ions at m/z 152.8 and m/z 109 for gentisic acid. This compound reduces fat accumulation in adipose tissues by inhibiting key enzymes such as α-amylase and α-glucosidase involved in carbohydrate digestion. Caffeic acid 4-O-glucuronide (*m/z* 355.07) produced ions of m/z 193 and *m/z* 123, corresponding to loss of carboxyl group and glucuronide moiety. Chlorogenic acid (*m/z* 353.09) showed the fragment ions of *m/z* 191 correspond to the caffeic acid moiety after the loss of quinic acid and *m/z* 135 represents the loss of quinic acid moiety as previously described by Yunus et al.

(2021). Similarly, Karageçili et al. (2023a), Ozden et al. (2023) found Chlorogenic acid at *m/z* 353. Chlorogenic acid is an ester caffeic acid and quinic acid known to inhibit glucose absorption and improve insulin sensitivity, however, the replacement of quinic acid with glucuronic acid can produce chlorogenic acid mimics with increased antioxidant activity (Cao et al., 2019).

3.4.2 Flavonoids

Eight flavonoids were identified in the selected plant extracts and their structures were confirmed by fragment patterns. Prodelphiniline was identified at *m/z* 609.13, producing fragment ions at *m/z* 175 which represents a huge loss of major structural components and at *m/z* 333 indicating the loss of sugar moieties (Ancillotti et al., 2017). Procyanidin C1 exhibited *m/z* 865.2 which formed fragment ions at *m/z* 287 and *m/z* 577 representing catechin unit and partial loss of dimetric structure respectively (Zhang et al., 2023). Myrciacitrin I (*m/z* 477.14) showed daughter ions of *m/z* 109 which indicated a major loss of sugar moiety and *m/z* 175 suggested further loss in flavonoid core structure. Apigenin 7-O-(6"-O-acetylglucoside) was detected at m/z 473.11 and showed fragment ions of *m/z* 175 and *m/z* 239 by the loss of acetyl or glucose group and additional fragmentation of flavonoid core structure respectively. Tricin 7-Glucoside (*m/z* 491.12) exhibited daughter ions of *m/z* 109 and 161 representing a loss of glucose moiety and flavonoid glycosides respectively. The compound malvidin 3-rutinoside (m/z 635.20) produced fragment ions at *m/z* 133 which represented the loss of glycosidic bonds of flavonoids and *m/z* 279 indicating additional loss within the anthocyanin structure (Ling et al., 2009). Quercetin 3-O-alpha-(6'''-Caffeoylglucosyl-beta-1,2-Rhamnoside) identified at *m/z* 771.18 which produced daughter ions *m/z* 255 and m/z 609 by the loss of rhamnoside or caffeoyl groups as previously described by Li et al. (2021). Quercitrin (*m/z* 447.09) exhibited fragmentation at *m/z* 146, indicating a major loss of glycosidic bond, and at *m/z* 255, confirming a core flavonoid structure. Quercitrin is the most abundant form of a glycoside of quercetin, quercetin O-glycoside is that quercetin substituted at position 3 via a glycosidic bond to the alpha-L-rhamnosyl moiety (De Paula Alves et al., 2022). These flavonoids exhibit antioxidant activities, anti-obesity, and anti-inflammatory properties by regulating lipid metabolism, decreasing adipogenesis through reducing the expression of PPARγ and C/EBPα, and pro-inflammatory cytokines (Toma et al., 2020). Additionally, procyanidin C1, prodelphiniline, and malvidin 3-rutinoside decrease the level of reactive oxygen species by upregulating superoxide dismutase (SOD) in endothelial cells (Merecz-Sadowska et al., 2023).

3.4.3 Terpenoids/Triterpenoids

Terpenoids are bioactive compounds known for their pharmacological activities and therapeutic effects in regulating lipid metabolism and reducing oxidative stress (Yao and Liu, 2022). Geranyl arabinopyranosyl-glucoside (*m/z* 447.23) showed fragmented ions of *m/z* 113 suggesting the removal of a larger portion of a molecule, potentially associated with core sugar unit and hydrocarbon chain, and *m/z* 293 indicated a further loss of the glucoside moiety (Stranska et al., 2021). This compound has been documented to increase insulin sensitivity by inhibiting protein tyrosine phosphatase 1B (PTP1B) (Genovese et al., 2021). The compound lancemaside G (*m/z* 1283.59), triterpene saponins (*m/z* 1283.59), scillascilloside E2 (*m/z* 1269.58) and glucosyl (2E,6E,10x)-10,11-Dihydroxy-2,6-Farnesadienoate (*m/z* 431.23) exhibited daughter ion at *m/z* 187, m/z 113, m/z 113 and 147 respectively which indicated a loss of larger portion from the core triterpene structure (Raheem et al., 2019). The observed fragmentation pattern of these compounds corroborates the structural identities of triterpene saponins which are recognized for their anti-obesity and anti-inflammatory properties.

3.4.4 Fatty Acids

Fatty acids are classified as carboxylic acids with aliphatic tails of different lengths, for example, carboxylic acids with aliphatic tails of less than 6 carbons are referred to as short-chain fatty acids (Layden et al., 2013). The current results exhibited the long chain fatty acids including, corchorifatty acid F (*m/z* 327.22), 9,12,13-triHOME (*m/z* 329.23) and gallicynoic acid F (*m/z* 343.21) at similar fragments of *m/z* 146 which suggested common structural element, potential associated with fatty acid's hydrocarbon chain and *m/z* 174 indicated the loss of carbon dioxide. These compounds play an essential role in lipid metabolism and reduce the production of proinflammatory cytokines such as TNF-α and IL-6 (Vasan et al., 2019, Zhang et al., 2024). (9S,10S) -9,10-Dihydroxyoctadecanoate (m/z 315.25) produced daughter ions at *m/z* 174 and *m/z* 243 respectively representing the breakdown of carbon bonds and loss of the major alkyl group (Burdge and Calder, 2015). This compound is known to be linked with insulin sensitivity through the activation of the AMP-activated protein kinase (AMPK) pathway to promote glucose uptake by the muscle and fatty acid oxidation (Ke et al., 2018).

3.4.5 Saponins

Beta-D-glucose pentaacetate (m/z 389.1) generated daughter ions at m/z 141 through the loss of acetylated glucose moiety. The presence of acetylated glucose in the structure of this compound may influence glucose metabolism by regulating α-amylase and α-glucosidase (Wang et al., 2018). The compound beta-d-xylopyranosyl-(1->2) (m/z 1163.55) showed fragmentation at *m/z* 101 and *m/z* 149 with the loss of xylose backbone. The structural fragmentation is significant because xylose may inhibit the hydrolysis of glycosidic bonds by digestive enzymes in the small intestine, thereby reaching the colon intact to be fermented by beneficial anaerobic bacteria (Arjona et al., 2007). The fermentation process promotes gut microbiota which manages metabolic disorders and regulation of inflammation. Trigoneoside XIIIa identified at *m/z* 1271.59 exhibited fragment ions at *m/z* 293 representing the loss of sugar fragments which confirmed complex glycosidic structures, particularly of saponins (Kang et al., 2013). This compound reduces pro-inflammatory cytokines such as TNF-α and IL6 by regulating the activities of NFkB.

3.4.6 Other polyphenolic compounds

Broussonetine F (m/z 360.24) exhibited product ions at *m/z* 133 indicating the minimal loss of alkaloids and at *m/z* 281 confirming the core alkaloid structure (Laili et al., 2023). This compound suppressed inflammation in RAW264.7 cells by inhibiting extracellular signal-regulated kinase (ERK) and p38 mitogen-activated protein kinase (p38 MAPK) (Huang et al., 2019). Daucic Acid (m/z 203.02) exhibited a fragment ion identical to the parent ion suggesting a stable structure. The compound mycophenolic acid O-acyl-glucuronide (*m/z* 495.15) produced daughter ions at *m/z* 151 and *m/z* 297, indicating loss of glucuronide moiety. Mycophenolic acid is commonly used as an immunosuppressant, preventing organ rejection after transplanting by inhibiting the enzyme inosine monophosphate dehydrogenase (IMPDH) that promotes the proliferation of T-cell and B-cell (Shigesaka et al., 2020). Suppressing the immune cell activity may reduce inflammatory response and improve insulin sensitivity and metabolic health. D-Linalool 3-Glucoside (m/z 315.18) exhibited fragment ion at *m/z* 146 representing the loss of a small group of potential glucoside or linalool moiety. The fragmentation of glucose moiety may increase the bio-availability of linalool, suggesting its potential to mitigate the activities of NF-kB and MAPK and improve insulin sensitivity (Sabogal-Guáqueta et al., 2018).

511 Table 2. Based on the LCMS analysis, twenty-seven compounds were discovered from different plant parts of *P. prunelloides, E.*
512 *autumnalis, M. plumbea,* and *H. hemerocallidea* to have the potential to prevent or treat obesity-induced inflammation. All analyses
513 were conducted in triplicates.

Compound	**Formula**	**Average Rt(min)**	**Ionization ESI (+/-)**	**Molecular weight (g/mol)**	**Average M/z**	**Plant part**
Phenolic Acids						
Gentesic acid 5-O-glucoside	C13H16O9	3.4	$[M-H]^-$	316.26	315.07	HL, HR, PL, PR
Caffeic acid 4-O-glucuronide	C15H16O10	3.7	$[M-H]^-$	356.28	355.07	HL, EL, PL
Chlorogenic acid	C16H18O9	4.0	$[M-H]^-$	354.31	353.09	HL, HR, PL, ML, MR
Flavonoids						
Prodelphiniline	C30H26O14	3.0	$[M-H]^-$	610.50	609.13	PL, PR
Procyanidin C1	C45H38O18	3.2	$[M-H]^-$	866.80	865.20	PL, PR
Myrciacitrin I	C23H26O11	4.1	$[M-H]^-$	478.45	477.14	HL, HR, ML, MR
Apigenin 7-O-(6"-O-acetylglucoside)	C23H22O11	4.3	$[M-H]^-$	474.40	473.11	HR, HL, EL, ML
Tricin 7-glucoside	C23H24O12	4.3	$[M-H]^-$	492.40	491.12	HL, HR
Malvidin 3-rutinoside	C30H36O15	5.1	$[M-H]^-$	636.60	635.20	HR, HL, EL, ER, ML, MR
quercetin 3-O-alpha-(6'-caffeoylglucosyl-beta-1,2-rhamnoside)	C36H36O19	5.2	$[M-H]^-$	772.70	771.18	HL, HR, ML, MR
Quercitrin	C21H20O11	5.2	$[M-H]^-$	448.40	447.09	HR, EL, PL
Terpenoids/Triterpenoids						

Geranyl arabinopyranosyl-glucoside	C21H36O10	6.5	$[M-H]^+$	448.50	493.23	HL, HL, ER, ML, MR
Lancemaside G	C57H90O27	7.5	$[M-H]^-$	1207.3	1205.56	EL, ER, ML, MR
Triterpene saponins (UNPD166363)	C59H96O30	7.3	$[M-H]^+$	1283.59	1283.59	EL, ER, ML, MR
Scillascilloside E2	C57H92O28	7.6	$[M-H]^+$	1225.30	1269.58	HL, EL, ER, ML, MR
Glucosyl (2E,6E,10x)-10,11-dihydroxy-2,6-farnesadienoate	C21H36O9	7.5	$[M-H]^-$	432.50	431.23	HL, HR, EL, ER, PL, PR, ML, MR
Fatty Acids						
Corchorifatty acid F	C18H32O5	7.0	$[M-H]^-$	328.44	327.22	HL, HR, EL, ER, PL, PR, ML, MR
9,12,13-TriHOME	C18H34O5	7.4	$[M-H]^-$	330.50	329.23	HL, HR, EL, ER, PL, PR, ML, MR
(9S,10S)-9,10-dihydroxyoctadecanoate	C18H36O4	9.7	$[M-H]^-$	315.50	315.25	HL, HR, EL, ER, PL, PR, ML, MR
Gallicynoic acid F;(-)-Gallicynoic acid F	C18H32O6	9.0	$[M-H]^-$	344.40	343.21	HL, HR, EL, ER, PL, PR, ML, MR
Saponins						
Beta-D-Glucose pentaacetate	C16H22O11	3.1	$[M-H]^-$	390.34	389.11	PL, PR
BETA-D-XYLOPYRANOSYL-(1->2)	C55H88O26	7.1	$[M-H]^-$	1165.30	1163.55	EL, ER
Trigoneoside XIIIa	C57H94O28	7.9	$[M-H]^-$	1227.3	1271.59	HL, EL, ER, ML, MR
Other polyphenols						
Broussonetine F	C18H35NO6	5.8	$[M-H]^-$	361.5	360.24	HL, HR, EL, ER, PL, PR, ML, MR

Daucic acid	C7H8O7	2.2	$[M-H]^-$	204.13	203.02	HL, HR, PL
Mycophenolic acid O-acyl-glucuronide	C23H28O12	3.9	$[M-H]^-$	496.50	495.15	HL, HR, ML, MR
D-Linalool 3-glucoside	C16H28O6	8.0	$[M-H]^-$	316.39	315.18	HL, HR, EL, ER, PL, PR, ML, MR

514 Abbreviations: HL, *Hypoxis hemerocallidea* leaves; HR, *Hypoxis hemerocallidea* roots; PL, *Pentanisia prunelloides* leaves; PR,
515 *Pentanisia prunelloides* roots; EL, *Eucomis autumnalis* leaves; ER, *Eucomis autumnalis* roots; ML, *Merwilla plumbea* leaves; MR,
516 *Merwilla plumbea* roots; M-H, deprotonated molecular ion; M/z, mass-to-charge ratio; Rt, retention time; ESI, electrospray ionization.

4. Conclusion

The study successfully identified and characterised polyphenolic compounds in *P. prunelloides, E. autumnalis, M. plumbea,* and *H. hemerocallidea* using LC-MS/MS and quantified their concentrations via UV spectrophotometry. The results revealed significant variation in phenolic acids, flavonoids, terpenoids, saponins, fatty acids, and other polyphenols among plant species and parts with *P. prunelloides* exhibiting the highest concentrations. These variations in antioxidant potential and metabolite distribution support the hypothesis that specific plant species and parts accumulate different levels of secondary metabolites and are influenced by genetic expression, enzymatic activity, and environmental stress adaptation.

These findings have significant implications for medicinal and pharmaceutical applications, as the identified polyphenols exhibit potential in lipid metabolism regulation, oxidative stress protection, and anti-inflammatory activity. However, considering sustainability, it is preferable to harvest leaves instead of roots if they provide an adequate compound concentration to ensure long-term conservation. Among the plant species analysed, *P prunelloides* exhibited the highest metabolite concentration, making it a strong candidate for further research into its therapeutic applications. Future research should validate the bioactivity of its key compounds in vivo, explore seasonal variations, and assess optimal harvesting practices for sustainable utilization of these medicinal plants.

Acknowledgments

The Authors acknowledge Mrs Alison Young for assisting with plant identification and harvesting.

5. References

Aborode, A. T., Favour Obianuju, A., Onyeaka, H., Fasawe, A. S., Adegoye, G. A., Oko, C.,Uro-Chukwu, H. C., 2023. Obesity and nutrition in the most remote parts of Africa. Frontiers in public health. 11, 1197367.

Al-Alimi, K., Abdul Razak, A., Saub, R.,Alabsi, A., 2017. Tannins acid, ascorbic acid and fluoride from khat chewing plant. International Journal of Dental and Oral Health. 3.

545 Alamgir, A., 2018. Phytoconstituents active and inert constituents, metabolic pathways, chemistry
546 and application of phytoconstituents, primary metabolic products, and bioactive
547 compounds of primary metabolic origin: Therapeutic use of medicinal plants and their
548 extracts. Springer Cham. Chittagong Bangladesh, pp. 25-164.
549 Alaribe, F. N., Maepa, M. J., Mkhumbeni, N.,Motaung, S. C., 2018. Possible roles of *Eucomis*
550 *autumnalis* in bone and cartilage regeneration: A review. Tropical Journal of
551 Pharmaceutical Research. 17, 741-49.
552 Ancillotti, C., Ciofi, L., Rossini, D., Chiuminatto, U., Stahl-Zeng, J., Orlandini, S., Furlanetto,
553 S.,Del Bubba, M., 2017. Liquid chromatographic/electrospray ionization quadrupole/time
554 of flight tandem mass spectrometric study of polyphenolic composition of different
555 vaccinium berry species and their comparative evaluation. Analytical and Bioanalytical
556 Chemistry. 409, 1347-68.
557 Arjona, O., Gomez, A. M., Lopez, J. C.,Plumet, J., 2007. Synthesis and conformational and
558 biological aspects of carbasugars. Chemical reviews. 107, 1919-2036.
559 Bisht, K., Pandey, N., Gautam, S.,Lohani, P., 2024. Determination of polyphenols, reducing
560 potential and ft-ir analysis of green tea (camellia sinensis l.) leaves extract for nanoparticles
561 synthesis. Journal of Advances in Biology & Biotechnology. 27, 842-50.
562 Breton, J., Galmiche, M.,Déchelotte, P., 2022. Dysbiotic gut bacteria in obesity: An overview of
563 the metabolic mechanisms and therapeutic perspectives of next-generation probiotics.
564 Microorganisms. 10, 452.
565 Burdge, G. C.,Calder, P. C., 2015. Introduction to fatty acids and lipids. Intravenous Lipid
566 Emulsions. 112, 1-16.
567 Cao, X., Wu, C., Tian, Y.,Guo, P., 2019. The caffeic acid moiety plays an essential role in
568 attenuating lipid accumulation by chlorogenic acid and its analogues. RSC advances. 9,
569 12247-54.
570 Chen, L., Deng, H., Cui, H., Fang, J., Zuo, Z., Deng, J., Li, Y., Wang, X.,Zhao, L., 2018.
571 Inflammatory responses and inflammation-associated diseases in organs. Oncotarget. 9,
572 7204.
573 Chowdhary, V., Alooparampil, S., Pandya, R. V.,Tank, J. G., 2021. Physiological function of
574 phenolic compounds in plant defense system: Badria, F. A. Phenolic compounds:

Chemistry, synthesis, diversity, non-conventional applications, and non-conventional sources. IntechOpen. London United Kingdom, pp. 185-92.

Csepregi, K., Kocsis, M.,Hideg, É., 2013. On the spectrophotometric determination of total phenolic and flavonoid contents. Acta Biologica Hungarica. 64, 500-09.

De Paula Alves, T., Toledo Martins Pereira, M., Sardou Charret, T., César Thurler Júnior, J., Freimann Wermelinger, G., Regina Baptista, A., Kaufmann Robbs, B., Sawaya, A. C., D'ávila Bitencourt Pascoal, V.,Cristina Rheder Fagundes Pascoal, A., 2022. Evaluation of the antiproliferative potential of eugenia pyriformis leaves in cervical cancer cells. Chemistry & Biodiversity. 19, e202200114.

Deng, Y.,Lu, S., 2017. Biosynthesis and regulation of phenylpropanoids in plants. Critical Reviews in Plant Sciences. 36, 257-90.

Genovese, M., Nesi, I., Caselli, A.,Paoli, P., 2021. Natural α-glucosidase and protein tyrosine phosphatase 1b inhibitors: A source of scaffold molecules for synthesis of new multitarget antidiabetic drugs. Molecules. 26, 4818.

Ghuman, S., Ncube, B., Finnie, J. F., Mcgaw, L. J., Coopoosamy, R. M.,Van Staden, J., 2016. Antimicrobial activity, phenolic content, and cytotoxicity of medicinal plant extracts used for treating dermatological diseases and wound healing in kwazulu-natal, south africa. Frontiers in pharmacology. 7, 320.

Gohari, A., Hajimehdipoor, H., Saeidnia, S., Ajani, Y.,Hadjiakhoondi, A., 2011. Antioxidant activity of some medicinal species using frap assay. Journal of Medicinal Plants. 10, 1-9.

Gulcin, İ., 2020. Antioxidants and antioxidant methods: An updated overview. Archives of toxicology. 94, 651-715.

Gulcin, İ.,Alwasel, S. H., 2023. Dpph radical scavenging assay. Processes. 11, 2248.

Gulcin, I., Kaya, R., Goren, A. C., Akincioglu, H., Topal, M., Bingol, Z., Cetin Çakmak, K., Ozturk Sarikaya, S. B., Durmaz, L.,Alwasel, S., 2019. Anticholinergic, antidiabetic and antioxidant activities of cinnamon (cinnamomum verum) bark extracts: Polyphenol contents analysis by lc-ms/ms. International Journal of Food Properties. 22, 1511-26.

Hagerman, A., 2002. Teratogenic investigation of bay leaf (syzygium polyanthum wight.) ethanol extract on morphology of fetal mice (mus musculus l.) strain ddy: Tannin chemistry Miami University. Oxford Ohio USA, pp. 2-17.

Huang, S.-P., Xin, G., Guo-Yin, K., Ya-Zhou, X., Yuan, X., Hao-Jie, W., Tao, P., Zhang, L.-Y.,Ying, L., 2019. Broussonin e suppresses lps-induced inflammatory response in macrophages via inhibiting mapk pathway and enhancing jak2-stat3 pathway. Chinese journal of natural medicines. 17, 372-80.

Jiang, X., Liu, Y., Wu, Y., Tan, H., Meng, F., Wang, Y. S., Li, M., Zhao, L., Liu, L.,Qian, Y., 2015. Analysis of accumulation patterns and preliminary study on the condensation mechanism of proanthocyanidins in the tea plant [camellia sinensis]. Scientific reports. 5, 8742.

Joint, F., 2000. Quantification of tannins in tree foliage. A laboratory manual for the fao/iaea co-ordinated research project on'use of nuclear and related techniques to develop simple tannin assays for predicting and improving the safety and efficiency of feeding ruminants on tanniniferous tree foliage'.

Kang, L.-P., Zhao, Y., Pang, X., Yu, H.-S., Xiong, C.-Q., Zhang, J., Gao, Y., Yu, K., Liu, C.,Ma, B.-P., 2013. Characterization and identification of steroidal saponins from the seeds of trigonella foenum-graecum by ultra high-performance liquid chromatography and hybrid time-of-flight mass spectrometry. Journal of Pharmaceutical and Biomedical Analysis. 74, 257-67.

Karageçili, H., İzol, E., Kireçci, E.,Gülçin, İ., 2023a. Antioxidant, antidiabetic, antiglaucoma, and anticholinergic effects of tayfi grape (vitis vinifera): A phytochemical screening by lc-ms/ms analysis. Open Chemistry. 21, 20230120.

Karagecili, H., Yılmaz, M. A., Ertürk, A., Kiziltas, H., Güven, L., Alwasel, S. H.,Gulcin, İ., 2023b. Comprehensive metabolite profiling of berdav propolis using lc-ms/ms: Determination of antioxidant, anticholinergic, antiglaucoma, and antidiabetic effects. Molecules. 28, 1739.

Kasote, D. M., Katyare, S. S., Hegde, M. V.,Bae, H., 2015. Significance of antioxidant potential of plants and its relevance to therapeutic applications. International journal of biological sciences. 11, 982.

Kausar, H., Ambrin, G., Okla, M. K., Soufan, W., Al-Ghamdi, A. A.,Ahmad, A., 2020. Metabolic flux analysis of catechin biosynthesis pathways using nanosensor. Antioxidants. 9, 288.

Ke, C., Zhu, X., Zhang, Y.,Shen, Y., 2018. Metabolomic characterization of hypertension and dyslipidemia. Metabolomics. 14, 1-11.

635 Kim, K. A., Tran, N. K. S., Baek, J., Lee, S., Kang, K. S.,Kim, K. H., 2024. Proanthocyanidins
636 and phenolic compounds from the twigs of salix chaenomeloides and their anti-lipogenic
637 effects on 3t3-l1 preadipocytes. Nutrients. 16, 1036.
638 Laili, E. R., Ekasari, W., Nuengchamnong, N.,Suphrom, N., 2023. Chemical profiles and in vitro
639 cholinesterase inhibitory activities of the flower extracts of cassia spectabilis. Advances in
640 Pharmacological and Pharmaceutical Sciences. 2023, 1-9.
641 Layden, B. T., Angueira, A. R., Brodsky, M., Durai, V.,Lowe Jr, W. L., 2013. Short chain fatty
642 acids and their receptors: New metabolic targets. Translational Research. 161, 131-40.
643 Leyva-Jiménez, F. J., Ruiz-Malagón, A. J., Molina-Tijeras, J. A., Diez-Echave, P., Vezza, T.,
644 Hidalgo-García, L., Lozano-Sánchez, J., Arráez-Román, D., Cenis, J. L., Lozano-Pérez, A.
645 A., Rodríguez-Nogales, A., Segura-Carretero, A.,Gálvez, J., 2020. Comparative study of
646 the antioxidant and anti-inflammatory effects of leaf extracts from four different morus
647 alba genotypes in high fat diet-induced obesity in mice. Antioxidants. 9, 733.
648 Li, Y., Li, P., Yang, K., He, Q., Wang, Y., Sun, Y., He, C.,Xiao, P., 2021. Impact of drying methods
649 on phenolic components and antioxidant activity of sea buckthorn (hippophae rhamnoides
650 l.) berries from different varieties in china. Molecules. 26, 7189.
651 Lim, H. H., Yang, S. J., Kim, Y., Lee, M.,Lim, Y., 2013. Combined treatment of mulberry leaf
652 and fruit extract ameliorates obesity-related inflammation and oxidative stress in high fat
653 diet-induced obese mice. Journal of medicinal food. 16, 673-80.
654 Ling, Y., Ren, C., Mallery, S. R., Ugalde, C. M., Pei, P., Saradhi, U. V., Stoner, G. D., Chan, K.
655 K.,Liu, Z., 2009. A rapid and sensitive lc–ms/ms method for quantification of four
656 anthocyanins and its application in a clinical pharmacology study of a bioadhesive black
657 raspberry gel. Journal of Chromatography B. 877, 4027-34.
658 Mashitoa, F. M., Shoko, T., Shai, J. L., Slabbert, R. M.,Sivakumar, D., 2021. Changes in phenolic
659 metabolites and biological activities of pumpkin leaves (cucurbita moschata duchesne ex
660 poir.) during blanching. Frontiers in Nutrition. 8, 641939.
661 Matyanga, C. M., Morse, G. D., Gundidza, M.,Nhachi, C. F., 2020. African potato (hypoxis
662 hemerocallidea): A systematic review of its chemistry, pharmacology and ethno medicinal
663 properties. BMC complementary medicine and therapies. 20, 1-12.

Mbhele, N. 2021. Ethnobotanical survey, pharmacological evaluation and chemical characterization of selected medicinal plants used in south africa in the management of wounds. Doctoral Thesis, University of Johannesburg (South Africa).

Merecz-Sadowska, A., Sitarek, P., Kowalczyk, T., Zajdel, K., Jęcek, M., Nowak, P.,Zajdel, R., 2023. Food anthocyanins: Malvidin and its glycosides as promising antioxidant and anti-inflammatory agents with potential health benefits. Nutrients. 15, 3016.

Mora, J., Pott, D. M., Osorio, S.,Vallarino, J. G., 2022. Regulation of plant tannin synthesis in crop species. Frontiers in Genetics. 13, 870976.

Moyo, M., Amoo, S., Ncube, B., Ndhlala, A., Finnie, J.,Van Staden, J., 2013. Phytochemical and antioxidant properties of unconventional leafy vegetables consumed in southern africa. South African Journal of Botany. 84, 65-71.

Mpofu, S. J., Msagati, T. A.,Krause, R. W., 2014. Cytotoxicity, phytochemical analysis and antioxidant activity of crude extracts from rhizomes of elephantorrhiza elephantina and pentanisia prunelloides. African Journal of Traditional, Complementary and Alternative Medicines. 11, 34-52.

Ncube, B., Finnie, J.,Van Staden, J., 2011. Seasonal variation in antimicrobial and phytochemical properties of frequently used medicinal bulbous plants from south africa. South African Journal of Botany. 77, 387-96.

Ndoh, S.,Samrc, I., 2017. South africa demographic and health survey 2016: Key indicator report. Pretoria, south africa and rockville, maryland, USA: National department of health (ndoh). Statistics South Africa (SSA), South African Medical Research Council (SAMRC) and ICF.

Nugrahini, N. I. P., Rohman, M. S., Wardani, A. K., Martati, E.,Chomsy, I. N., 2024. The optimal dose of the green tea and coffee extracts to suppress the expression of ppar-γ and c/ebp-α on differentiated 3t3-l1 adipocytes. Trends in Sciences. 21, 7182-82.

Oliveira, A. K. D. S., De Oliveira E Silva, A. M., Pereira, R. O., Santos, A. S., Barbosa Junior, E. V., Bezerra, M. T., Barreto, R. S., Quintans-Junior, L. J.,Quintans, J. S., 2022. Anti-obesity properties and mechanism of action of flavonoids: A review. Critical Reviews in Food Science and Nutrition. 62, 7827-48.

Ozden, E. M., Bingol, Z., Mutlu, M., Karagecili, H., Köksal, E., Goren, A. C., Alwasel, S. H.,Gulcin, İ., 2023. Antioxidant, antiglaucoma, anticholinergic, and antidiabetic effects of

695 kiwifruit (actinidia deliciosa) oil: Metabolite profile analysis using lc-hr/ms, gc/ms and gc-
696 fid. Life. 13, 1939.
697 Podsędek, A., Zakłos-Szyda, M., Polka, D.,Sosnowska, D., 2020. Effects of viburnum opulus fruit
698 extracts on adipogenesis of 3t3-l1 cells and lipase activity. Journal of Functional Foods.
699 73, 104111.
700 Porter, L. J., Hrstich, L. N.,Chan, B. G., 1985. The conversion of procyanidins and prodelphinidins
701 to cyanidin and delphinidin. Phytochemistry. 25, 223-30.
702 Pratyusha, D. S.,Sarada, D. V., 2022. Myb transcription factors—master regulators of
703 phenylpropanoid biosynthesis and diverse developmental and stress responses. Plant cell
704 reports. 41, 2245-60.
705 Rabeta, M.,Faraniza, R. N., 2013. Total phenolic content and ferric reducing antioxidant power of
706 the leaves and fruits of garcinia atrovirdis and cynometra cauliflora. International Food
707 Research Journal. 20, 1691.
708 Raheem, D. J., Tawfike, A. F., Abdelmohsen, U. R., Edrada-Ebel, R.,Fitzsimmons-Thoss, V.,
709 2019. Application of metabolomics and molecular networking in investigating the
710 chemical profile and antitrypanosomal activity of british bluebells (hyacinthoides non-
711 scripta). Scientific reports. 9, 2547.
712 Rosen, E. D.,Spiegelman, B. M., 2014. What we talk about when we talk about fat. Cell. 156, 20-
713 44.
714 Sabogal-Guáqueta, A. M., Posada-Duque, R., Cortes, N. C., Arias-Londoño, J. D.,Cardona-
715 Gómez, G. P., 2018. Changes in the hippocampal and peripheral phospholipid profiles are
716 associated with neurodegeneration hallmarks in a long-term global cerebral ischemia
717 model: Attenuation by linalool. Neuropharmacology. 135, 555-71.
718 Sharma, K. P., John, P., Goswami, P.,Soni, M., 2017. Enzymatic synthesis of gallic acid from
719 tannic acid with an inducible hydrolase of enterobacter spp. Biocatalysis and
720 Biotransformation. 35, 177-84.
721 Shi, G., Liu, G., Liu, H., Wang, L., Kuwantai, A., Du, Y., Wang, L., Xi, X.,Chai, R., 2024. A new
722 glucosyltransferase ugt78 from iris sanguinea is a putative negative regulator in cadmium
723 stress response. Journal of Forestry Research. 35, 77.
724 Shigesaka, M., Ito, T., Inaba, M., Azuma, Y., Tsujimoto, S., Tanaka, A., Son, Y., Ozaki,
725 Y.,Nomura, S., 2020. Ab0141 mycophenolate mofetil, inhibitor of inosine-5'-

monophosphate dehydrogenase, regulates differentiation, maturation and function of human dendritic cell subsets. Annals of the Rheumatic Diseases. 79, 1370-71.

Singh, M., Thrimawithana, T., Shukla, R.,Adhikari, B., 2020. Managing obesity through natural polyphenols: A review. Future Foods. 1, 100002.

Smith, M. H., Myrick, J. W., Oyageshio, O., Uren, C., Saayman, J., Boolay, S., Van Der Westhuizen, L., Werely, C., Möller, M.,Henn, B. M., 2023. Epidemiological correlates of overweight and obesity in the northern cape province, south africa. PeerJ. 11, e14723.

Stranska, M., Lovecka, P., Vrchotova, B., Uttl, L., Bechynska, K., Behner, A.,Hajslova, J., 2021. Bacterial endophytes from vitis vinifera l.–metabolomics characterization of plant-endophyte crosstalk. Chemistry & Biodiversity. 18, e2100516.

Toma, L., Sanda, G. M., Niculescu, L. S., Deleanu, M., Sima, A. V.,Stancu, C. S., 2020. Phenolic compounds exerting lipid-regulatory, anti-inflammatory and epigenetic effects as complementary treatments in cardiovascular diseases. Biomolecules. 10, 641.

Vasan, S. K., Noordam, R., Gowri, M. S., Neville, M. J., Karpe, F.,Christodoulides, C., 2019. The proposed systemic thermogenic metabolites succinate and 12,13-dihome are inversely associated with adiposity and related metabolic traits: Evidence from a large human cross-sectional study. Diabetologia. 62, 2079-87.

Wang, M., Zhang, L., Li, Y.,Gu, L., 2018. Imidazole promoted efficient anomerization of β-d-glucose pentaacetate. European journal of chemistry. 7, e202202508y.

Yao, P.,Liu, Y., 2022. Terpenoids: Natural compounds for non-alcoholic fatty liver disease (nafld) therapy. Molecules. 28, 272.

Yildiz-Ozturk, E., Nalbantsoy, A., Tag, O.,Yesil-Celiktas, O., 2015. A comparative study on extraction processes of stevia rebaudiana leaves with emphasis on antioxidant, cytotoxic and nitric oxide inhibition activities. Industrial Crops and Products. 77, 961-71.

Yunus, S. N. M., Zolkeflee, N. K. Z., Jaafar, A. H.,Abas, F., 2021. Metabolite identification in different fractions of ficus auriculata loureiro fruit using the 1h-nmr metabolomics approach and uhplc-ms/ms. South African Journal of Botany. 138, 348-63.

Zhang, W., Cheng, W., Li, J., Huang, Z., Lin, H.,Zhang, W., 2024. New aspects characterizing non-obese nafld by the analysis of the intestinal flora and metabolites using a mouse model. Msystems. 9, e01027-23.

Zhang, X., Su, M., Du, J., Zhou, H., Li, X., Zhang, M., Hu, Y.,Ye, Z., 2023. Profiling of naturally occurring proanthocyanidins and other phenolic compounds in a diverse peach germplasm by lc-ms/ms. Food chemistry. 403, 134471.

Zielinska-Blizniewska, H., Sitarek, P., Merecz-Sadowska, A., Malinowska, K., Zajdel, K., Jablonska, M., Sliwinski, T.,Zajdel, R., 2019. Plant extracts and reactive oxygen species as two counteracting agents with anti-and pro-obesity properties. International journal of molecular sciences. 20, 4556.

Comparative profiling of bioactive compounds and antioxidant activity of extracts from selected medicinal plants: implications for mitigating obesity-related inflammation

Mngoma, Mlungisi F.

2025-06

Mngoma MF, Magwaza LS, Mditshwa A, et al., (2025) Comparative profiling of bioactive compounds and antioxidant activity of extracts from selected medicinal plants: implications for mitigating obesity-related inflammation. South African Journal of Botany, Volume 181, June 2025, pp. 162-171

https://doi.org/10.1016/j.sajb.2025.04.023