

Proximate and elemental composition of leaf, corm, root and peel of *Hypoxis hemerocallidea*: A Southern African multipurpose medicinal plant

Gloria Aderonke Otunola* and Anthony Jide Afolayan

Medicinal Plants and Economic Development (MPED) Research Centre, Department of Botany, University of Fort Hare, Alice, South Africa

Abstract: *Hypoxis hemerocallidea* also known as African potato is a medicinal plant widely distributed in Southern Africa, which has enjoyed long usage as a traditional multipurpose herbal medicine. This study evaluated the leaf, corm, peel and root of *H. hemerocallidea* for their nutritional attributes. Crude protein was highest in leaf (5.56%), followed by peel (2.79%), root (2.30%) and corm (1.79%) respectively. Crude fat ranged from 0.40% in root to 1.88% in leaf, while ash and acid detergent fibre (ADF) were highest in corm (16.77% and 49.75%) and lowest in root (3.20% and 5.46%) respectively. Neutral detergent fibre (NDF) was highest in leaf (55.47%), followed by corm (52.38%), peel (35.23%) and root (10.51%); while total carbohydrate calculated as non-fibre carbohydrate was highest in the root. The corm had the highest content ($P<0.05$) of calcium, zinc, copper and manganese, the root exhibited the highest content of magnesium, potassium and iron, while sodium and phosphorus content was highest in the leaf. The study revealed that *H. hemerocallidea* leaf, corm, peel and root are good sources of nutrients and minerals for humans and animals. This implies that the plant as a whole could be more effective therapeutically than the corm alone.

Keywords: *Hypoxis hemerocallidea*, nutritional attributes, medicinal plant, mineral composition.

INTRODUCTION

Traditional medicine plays a critical role in the health care delivery system of the general population in most parts of Africa. This is very true of South Africa because of the increased burden of chronic and communicable diseases such as diabetes, cardiovascular diseases, obesity and HIV/AIDS. In recent times, there has been an increase in the study of plant foods with nutraceutical, pharmaceutical, nutritional and functional properties. Many wild plants with multi-functional properties are now gaining recognition and usage. *H. hemerocallidea* is one of such plants which has recently become a subject of scientific study and is potentially an important breakthrough in the field of medicinal plants.

Also known as African potato, *Hypoxis hemerocallidea* is an African medicinal plant widely distributed in South Africa, which has enjoyed long usage as a traditional herbal medicine. The plant is characterized by strap-like leaves, bright yellow, star-shaped flowers and a tuberous root stock or corm erroneously referred to as African potato because of its shape (Van Wyk *et al.*, 2002; Owira and Ojewole, 2009). *H. hemerocallidea* grows in the open grass and woodlands and is widespread in the Eastern Cape, Free State, Mpumalanga, Gauteng and Limpopo Provinces of South Africa. It also grows in Botswana, Lesotho, Mozambique and Swaziland.

Hypoxis hemerocallidea (fig. 1) is a hardy, perennial and

herbaceous corm/tuberous plant with yellow star-shaped flowers in early summer, mid and late spring. It grows well in semi-shade and direct sun, and prefers medium levels of water. The leaves are green in spring, summer and autumn with rough thick hairs (Russell *et al.*, 1987).

H. hemerocallidea corm has been used by traditional healers in southern Africa for the treatment and management of various ailments including tuberculosis, diabetes, cancer, urinary tract infections, prostrate hypertrophy and testicular tumors as well as an immune booster in HIV/AIDS.

Other uses of the plant in the treatment of rheumatoid arthritis, endometriosis and premenstrual syndrome, mental disorders, impotence, anti-inflammation and as a worm expeller have been documented (Ojewole 2006, Ojewole *et al.*, 2006; Steenkamp *et al.*, 2006; Nair *et al.*, 2007; Singh 2007). Traditionally, the corms are chopped into pieces, boiled for about twenty minutes and the decoction consumed orally.

Extensive studies on the pharmacological, phytochemical, hypoglycaemic, antioxidant, anticancer, and anti-diabetic properties as well as the β -sitosterol, monoterpene glycosides and zeatin content of *H. hemerocallidea* have been reported (Pegel 1973; Van Staden 1981; Drewes *et al.*, 1984; Musabayane *et al.*, 2005; Boukes *et al.*, 2008). However, there is a dearth in the literature on the proximate and elemental composition of the different parts of the plant. This study was therefore conducted to

*Corresponding author: e-mail: gotunola@ufh.ac.za

assess the nutritional and elemental composition as well as their variations in different parts of *H. hemerocallidea*.

MATERIALS AND METHODS

H. hemerocallidea whole plant was collected from the wild in Alice in the Eastern Cape Province of South Africa. The plant was identified by Prof DS Grierson of the Department of Botany and voucher specimen (Otn.2013/04) was deposited at the Giffen herbarium of the University of Fort Hare. The plant was separated into leaves, corm, peels and roots; each part was dried in the oven at 45°C for 72h, then milled into fine powder and stored in airtight glass bottles at 4°C till needed for analysis. All reagents used in the study were of analytical grade.

Proximate analysis

Powdered *H. hemerocallidea* leaf, corm, peels and roots were assessed for crude protein (CP), crude fat (CF), ash and crude fibre on 100% dry matter (DM) basis according to methods described by AOAC (2000). Neutral detergent fibre (NDF) and acid detergent fibre (ADF) were determined according to the methods of Soest and Robertson (1980). Total carbohydrate (non-fibre-NFC) was calculated as $100 - [(NDF-ADF-CP)+CP+Fat+Ash]$. All determinations were in triplicates.

Mineral elements analysis

The macro and micro elements of the various parts of *H. hemerocallidea* were determined as described by Okalebo (2002) using Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES, Varian 710-ES Series). All determinations were in triplicates.

STATISTICAL ANALYSIS

Results were expressed as means $\pm$ standard deviation of three determinations. One-way analysis of variance was used to determine the differences of means among the samples. A significant difference was considered at the level of $P < 0.05$. All analyses were carried out using MINITAB (Student Version 12 for Windows) Software.

RESULTS

Results for the proximate composition of leaf, corm, stem and peel of *H. Hemerocallidea* is presented in Table 1. Protein content varied significantly in all the parts and ranged from 2.30% to 5.66% in the roots and leaves respectively. Crude fat content was significantly low in all the samples; and followed the order leaf > corm > peel > root. Ash content was generally high and varied significantly ($P < 0.05$) in the different parts of the plant. The corm had the highest content of 16%, while the leaf, peel and roots had 14.85, 10.08 and 3.20 respectively. Fibre content was determined as neutral detergent fibre

(NDF) and acid detergent fibre (ADF). NDF varied significantly among the various parts with the root having the lowest value of 10.51%, peels 35.23, corm 52.38% and leaf 55.47%. These values were significantly different at $P < 0.05$. ADF content on the other hand was in the order corm > leaf > peels > roots. Carbohydrate was calculated as non-fibre carbohydrate (NFC) by subtracting the sum of crude protein, NDF-ADF, crude fat and ash from 100. NFC was highest in the roots (83.59%), followed by the peels (51.04%), while leaf and corm contents were 22.24% and 28.06% respectively.



Fig. 1: *Hypoxis hemerocallidea* Fisch.

Mineral analysis of leaf, corm, peel and root of *H. hemerocallidea* (table 2) showed that the Ca, Zn, Cu and Mn content of the corm was significantly higher compared to other parts of the plant. The roots exhibited a significantly high Mg, K, K:Ca:Mg ratio and Fe content, while the leaf was significantly high in Na and P. There were no significant ($P > 0.05$) differences in the values for Mg in leaf and peel; and corm and root; P in the root, corm and peel; Cu in peel and root; Mn in leaf and corm and Zn in leaf and root.

DISCUSSION

Plants play significant roles in maintaining health and are valuable components of the diet and folkloric medicines. These nutritional and healing properties of plants are attributed to their chemical composition. According to Pandey (2006), evaluating the proximate and nutritional contents of medicinal plants can help to understand the therapeutic properties of these plant species.

Crude protein content of the leaf of *H. hemerocallidea* which was the highest of the four parts investigated, was still relatively low. According to NRC (1989), crude protein less than 20% is an indication of low protein value. However, despite the low protein content in the parts investigated, each part can contribute to the protein

Table 1: Proximate composition of leaf, corm, peel and root of *H. hemerocallidea*

Parameters (%)	Leaf	Corm	Peel	Root
Crude Protein	5.56±0.10 ^a	1.79±0.13 ^b	2.79±0.11 ^c	2.30±0.08 ^d
Crude Fibre	55.47±0.20 ^a	52.38±0.02 ^b	35.23±0.07 ^c	10.51±0.15 ^d
Crude Fat	1.88±0.02 ^a	1.00±0.02 ^b	0.86±0.03 ^c	0.40±0.01 ^d
Ash	14.85±0.05 ^a	16.77±0.80 ^b	10.08±0.01 ^c	3.20±0.05 ^d
ADF	33.84±0.69 ^a	49.75±0.60 ^b	31.80±0.01 ^c	5.46±0.12 ^d
NDF	55.47±0.20 ^a	52.38±0.02 ^a	35.23±0.07 ^c	10.51±0.15 ^d
Carbohydrate (NFC)	22.24±0.24 ^a	28.06±0.07 ^b	51.04±0.02 ^c	83.59±0.25 ^d

*Values are means n=3, ± SD. Values along the same row with different superscripts are statistically different (P < 0.05). ADF-acid detergent fibre; NDF-neutral detergent fibre; NFC- non-fibre carbohydrate.

Table 2: Elemental content of leaf, corm, peel and root of *H. hemerocallidea*

Elements (mg/100g)	Leaf	Corm	Peel	Root
Macro elements				
Ca	1.59±0.02 ^a	1.72±0.10 ^b	0.59±0.03 ^c	0.97±0.01 ^d
Mg	0.10±0.02 ^a	0.17±0.02 ^b	0.10±0.02 ^a	0.19±0.02 ^{bc}
K	1.93±0.02 ^a	0.90±0.50 ^b	0.67±0.01 ^c	2.54±0.14 ^d
Na	1.14±0.06 ^a	0.14±0.02 ^b	0.06±0.01 ^c	0.65±0.02 ^d
K/Ca+Mg	0.56±0.08 ^a	0.23±0.10 ^b	0.45±0.01 ^c	1.01±0.01 ^d
Micro elements				
P	0.07±0.02 ^a	0.03±0.01 ^b	0.03±0.01 ^b	0.03±0.01 ^b
Zn	18.00±1.00 ^a	45.00±2.00 ^b	30.67±0.58 ^c	16.00±1.00 ^a
Cu	8.00±1.00 ^a	16.00±1.00 ^b	9.00±0.08 ^c	9.00±1.00 ^c
Mn	96.67±7.64 ^a	96.67±7.64 ^a	41.00±1.00 ^b	63.00±1.00 ^c
Fe	901.0±1.00	1122.0±2.00	16.0±1.00	2315±2.00

*Values are means n=3, ± SD. Values along the same row with different superscripts are statistically different (P < 0.05).

requirements of the body. The protein content for the leaf also compared favourably with reports for most medicinal plants such as *Coriander sativum* (3.5%), *Hibiscus sabdariffa* (1.8%) and *Trigonella foenum-graecum* (5.4%) respectively (Ereifej et al., 2012); though higher values (23.36%) have been reported in *Ipomea hederacae* seeds (Zia-Ul-Haq et al., 2012).

The low crude fat content of all the parts investigated indicates that *H. hemerocallidea* is a poor source of fat. A study of the fatty acid profile of the little fat present may prove beneficial as they may contain valuable essential fatty acids. According to Egwuche et al. (2011), most vegetables are poor sources of lipids. This may be useful for individuals on weight-reducing diets, or those suffering from hyperlipidemia, obesity and cardiovascular complications.

Ash content is usually taken as an indication of the mineral content of a sample. The high ash content observed for corm, leaf and stem compared favourably with reports for other medicinal plants such as *Origano majorana* and *Salvia officinalis* (Ereifej et al., 2012) and indicate the high mineral content of the plant.

Neutral detergent fibre (NDF) is considered to be the entire fibre fraction of a feed. It is the structural

component of plants and predictor for voluntary intake because it provides bulk or fill (Ferguson 2013). In this study, the low NDF value of the root, implies that it will be easily digested and thus suggests the possibility of its inclusion in diets. Acid detergent fibre (ADF) consists of the least digestible plant components and are inversely related to digestibility. Low ADF values are higher in energy; this implies that the root is likely to increase the energy value of any diet it is added to compared with the peel, corm and leaf. Dietary fibre has been reported to aid absorption of minerals and reduce absorption of cholesterol (Aliyu et al., 2009). Results for non-fibre carbohydrate (NFC) revealed that the root had the highest carbohydrate content and compared favourably with other medicinal plants (Ajayi and Ojelere 2013; Aliyu et al., 2009).

The importance of dietary minerals are well documented. The high calcium content of the corm and leaf of *H. hemerocallidea* observed in this study, suggests that these two parts could supply or augment the necessary calcium needed for mediating vascular contraction, nerve-impulse transmission and glandular secretions. Potassium content was noticeably higher in all parts of the plant compared to sodium content. This means a low Na/K ratio which has been reported to be good for the maintenance of acid-base balance and lower incidences of hypertension (Choi

et al., 2011; Sarega *et al.*, 2012). Magnesium is important in fighting heart disease, stroke and in cell repair (Agunbiade *et al.*, 2012). The presence of Magnesium in the leaf, corm, peel and root of *H. hemerocallidea* could account for the use of the plant in the treatment of cardiovascular diseases. Magnesium (Mg) and calcium (Ca) antagonize each other in (re)absorption, inflammation and many other physiological activities. The low K/Ca/Mg ratio observed in this study implies that dietary magnesium, calcium, zinc and phosphorus bioavailability will not be compromised and there will be reduced risk of mortality (Dai *et al.*, 2013).

Iron is a component of myoglobin and haemoglobin needed for transport of oxygen and carbon dioxide (Ahmed and Chaudhary 2009; Kamshilov and Zaprudnova 2009). The high amount of iron found in the root, corm and leaf of *H. hemerocallidea* indicates that the specie could be a very good source of iron and could therefore be used to overcome iron deficiency.

Copper, zinc and manganese are essential trace elements needed in minute amounts by the human body for important biochemical functions. These three elements play important roles in reproduction and are closely interrelated (Osredkar and Sustar 2011; Ooi *et al.*, 2012). *H. hemerocallidea* is a very good source of Zn, Cu and Mn and their presence could account for the multifunctional medicinal uses of the plant especially in body building, pro-fertility and boosting of the immune system.

The current use of the corm of *H. Hermerocallidea* does not provide for its sustainable use since the use of the root, corm and whole-plant harvesting is more destructive to medicinal plants and results in resource exhaustion and even species extinction than collecting their leaves and flowers or buds (Baker *et al.*, 2007; Chen *et al.*, 2016). To this end, the sustainable use of *H. Hermerocallidea* should be considered by using the leaves as a remedy and alternative to the corm.

CONCLUSION

H. hemerocallidea corm is well known for its multipurpose therapeutic functions. This study has shown that the leaf, peel and root of the plant also possess high nutritional and mineral components. The presence of these nutrients and essential trace elements in this plant may readily account for most of the therapeutic properties. Therefore, all parts of the plant could be used for animal nutrition, tea production or dietary supplementations. This indicates that the various parts could also be integrated as functional foods into the diet. Whereas the corm alone is used traditionally for medicinal purposes, this study reveals that the whole plant could be more effective therapeutically and that the leaves compare favourably with the corm in terms of nutrient

and elemental contents. Further studies to assess the biological functions of each part is on-going.

ACKNOWLEDGEMENTS

This study was supported by the National Research Foundation (NRF) South Africa; and Govan Mbeki Research Development Centre (GMRDC), University of Fort Hare, South Africa.

REFERENCES

- Ahmed D and Chaudhary MA (2009). Medicinal and nutritional aspects of various trace metals determined in *Ajuga bracteosa*. *J. Appl. Sci. Res.*, 5(7): 864-869.
- Agunbiade OS, Ojezele OM, Ojezele JO and Ajayi AY (2012). Hypoglycaemic activity of *commelina africana* and *ageratum conyzoides* in relation to their mineral composition *Afr. Health. Sci.*, 12(2): 198-203.
- Ajayi IA and Ojelere OO (2013). Chemical composition of ten medicinal plant seeds from South-West Nigeria. *Adv. Life Sci. Tech.*, 10, (online).
- Aliyu AB, Musa AM, Sallau MS and Oyewale AO (2009). Proximate composition, mineral elements and anti-nutritional factors of *Anisopus mannii* N.E.Br. Asclepiadaceae). *Trend. Appl. Sci. Res.*, 4: 68-72.
- Association of Official Analytical Chemists (2000). Official Methods of Analysis of AOAC International 17th Ed; AOAC International, Gaithersbury, MD, USA.
- Baker DD, Chu M, Oza U and Rajgarhia V (2007). The value of natural products to future pharmaceutical discovery. *Nat. Prod. Rep.*, 24(6): 1225-44.
- Boukes GJ, Van de Venter M and Oosthuizen V (2008). Quantitative and qualitative analysis of sterols/sterolins and hypoxoside contents of three *Hypoxis* (African potato) spp. *Afr. J. Biotechnol.*, 7(11): 1624-1629.
- Chen S-L, Yu H, Luo H-M, Wu Q, Li C-F and Steinmetz A (2016). Conservation and sustainable use of medicinal plants: Problems, progress and prospects. *Chinese Medicine*, 11: 37.
- Choi M, Scholl UI, Yue P, Bjorklund P, Zhao B, Nelson-Williams C and Ji B (2011). K⁺ channel mutations in adrenal aldosterone-producing adenomas and hereditary hypertension. *Science*, 331: 768-772.
- Dai Q, Shu XO, Deng X, Xiang YB, Li H, Yang G, Shrubsole MJ and Ji B (2013). Modifying effect of calcium/magnesium intake ratio and mortality: A population-based cohort study. *Brit. Med. J. Open.*, 3(2): e002111.
- Drewes SE, Elliot E, Khan E, Dhlamini JTB and Gcumisa MSS (2008). *Hypoxis hemerocallidea* – not merely a cure for benign prostate hyperplasia. *J. Ethnopharmacol.*, 119: 593-598.
- Egwuche RU, Odetola AA and Erukainure OL (2011). Preliminary investigation into the chemical properties of *Peperomia pellucida*. *L. Res. J. Phytochem.*, 5: 48-53.

- Ereifej K, Ranya E, Taha R, Ali MA and Muhammad HA (2012). Minerals, proximate composition and their correlations of medicinal plants from Jordan. *J. Med. Plant. Res.*, **6** (47): 5757-5762.
- Ferguson J.D (2013). Carbohydrate Fractions in Dairy Rations. In: Carbohydrates in Rations: <http://research.vet.upenn.edu/Default.aspx?alias=research.vet.upenn.edu/dairynutrition>.
- Kamshilov IM and Zaprudnova RA (2009). Interspecies differences of haemoglobin buffer properties and of ion environment in some freshwater fish. *J. Evol. Biochem. Physiol.*, **45**(2): 242-244.
- Musabayane CT, Gondwe MM, Shode FO and Ojewole JAO (2005). Hypoglycaemic effects of *Hypoxis hemerocallidea* (Fisch. and C. A. Mey.) [Hypoxidaceae] corm ethanolic extract in rats. Presented at Society for Endocrinology BES London, UK. *Endocrine Abstracts.*, **10**: 34.
- Nair VPD, Dairam A, Agbonon A, Arnason JT, Foster BC and Kanfer I (2007a). Investigation of the antioxidant activity of African potato (*Hypoxis hemerocallidea*) corm. *J. Agric. Food. Chem.*, **55**: 1707-1711.
- National Research Council (1989). Committee on Dietary Allowances: Recommended Dietary Allowances 1989, 10th edn, National Academy of Science Press, Washington DC, USA.
- Ojewole JAO (2006). Antinociceptive, anti-inflammatory, and antidiabetic properties of *Hypoxis hemerocallidea* Fisch. & C.A. Mey (Hypoxidaceae) corm [African potato] aqueous extracts in mice and rats. *J. Ethnopharmacol.*, **103**: 126-134.
- Ojewole JA, Kamadyaapa DR and Musabayane CT (2006). Some *in vitro* and *in vivo* cardiovascular effects of *Hypoxis hemerocallidea* Fisch & CA Mey (Hypoxidaceae) corm (African Potato) aqueous extract in experimental animal models. *Cardiovasc J. South Africa.*, **17**(4):166-171.
- Okalebo JR, Gathua W and Woomer PL (2002). Laboratory methods of soil and plant analysis: A working manual. 2nd edn. TSBF-CIAT and SACRED Africa, Nairobi, Kenya.
- Ooi DJ, Iqbal S and Ismail M (2012). Proximate composition, Nutritional Attributes and Mineral composition of *Peperomia pellucida* L. (Ketumpangan Air) grown in Malaysia. *Molecule*, **17**: 11139-11145.
- Osredkar J and Sustar N (2011). Copper and zinc: Biological role and significance of copper/zinc imbalance. *J. Clin. Toxicol.*, **S3**: 001.
- Owira PMO and Ojewole JA (2009). African potato (*Hypoxis hemerocallidea* corm): A plant medicine for Modern and 21st century Disease of Mankind? A review. *Phytother. Res.*, **23**(2): 147-152.
- Pandey MAB, Abidi S and Singh RP (2006). Nutritional evaluation of leafy vegetables Paratha. *J. Human. Ecol.*, **19**: 155-156.
- Russell GE, Welman WG, Reitief E, Immelman KL, Germishuizen G, Pienaar BJ, Van Wyk M and Nicholas A (1987). List of species of southern African plants. *Memoirs Botanical Surv. SA.*, **2**(1-2): 1-152(pt. 1), 1-270(pt. 2).
- Sarega N, Iqbal S, Chan WK and Ismail M (2012). Assessment of nutritional and mineral composition of different parts of *Schismatoglottis bauensis*. *J. Med. Plant Res.*, **6**(9): 1576-1580.
- Singh Y (2007). Hypoxis (Hypoxidaceae) in Southern Africa: Taxonomic notes. *South Afr. J. Bot.*, **73**: 360-365.
- Steenkamp V, Gouws MC, Gulumian M, Elgorashi EE and Van Staden J (2006). Studies on antibacterial, anti-inflammatory and antioxidant activity of herbal remedies used in the treatment of benign prostatic hyperplasia. *J. Ethnopharmacol.*, **103**: 71-75.
- Van Soest PJ and Robertson JB (1980). Systems of analysis for evaluating fibrous feeds. In: Standardization of Analytical Methodology in Feeds (Pigden W.; Balch CC & Graham M eds.), International Research Development Center, Ottawa, Canada, pp.49-60.
- Van Staden J (1981). Constituents of *H. rooperi* a valuable plant in South Africa. *Deutsche Apothecary. ZTG*, **33**: 460-464. *Chemical Abstract* CA95 (19), 165595x.
- Van Wyk BE, Van Outshoorn B, Gericke N (2002). Medicinal plants of South Africa, 2nd edn. Briza Publications. Pretoria, pp.156-157.
- Venugopala KN, Rashmi V and Odhav B (2013). Review on Natural Coumarin Lead Compounds for Their Pharmacological Activity. *Bio Med Res. Intern.*, Article ID 963248, 14 pages, 2013. doi:10.1155/2013/963248
- Zia-Ul-Haq M, Riaz M and De Feo V (2012). *Ipomea herdacea* Jacq: A medicinal herb with promising health benefits. *Molecule*, **17**: 13132-13145.