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Nutritional Composition, Phytochemical Constituents and Cytotoxicity of Dipcadi glaucum (Burch. ex Ker Gawl.) Baker

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ABSTRACT: *This study aimed at evaluating the phytochemical, nutritional and cytotoxicity of* ***Dipcadi glaucum****, a wild edible species in Zimbabwe. The results of the proximate analysis show that D. glaucum is rich in nutrients, with high levels of crude protein (26.6% in leaves and 24% in bulbs) and ash (26.25% in leaves and 14% in bulbs), alongside moderate carbohydrate levels (35.55% in leaves and 43% in bulbs) and calorific values (295.6 kcal/100 g in leaves and 310.9 kcal/100 g in bulbs). The phytochemical analysis established presence of alkaloids, tannins, flavonoids, terpenoids, saponins, and steroids, suggesting potential health benefits and culinary applications Cytotoxicity was assessed using the brine shrimp lethality assay, showing an LC50 of 2.72 mg/ml for methanol bulb extracts and 1949.85 mg/ml for aqueous extracts. While both extracts were non-toxic based on assay thresholds, reports of potential toxicity to ruminants and the presence of alkaloids at higher concentrations warrant further research. Findings of this study suggest that* ***D. glaucum*** *is an important nutritional and mineral supplement, though additional research is needed to confirm its safety and suitability for human consumption.*

Keywords: ***Asparagaceae****,* ***Dipcadi glaucum****, phytochemicals, toxicity.*

INTRODUCTION

Dipcadi glaucum (Burch. ex Ker Gawl.) Baker belongs to the plant family Asparagaceae (Manning, 2022; Martínez-Azorín *et al*., 2023; Stedje and Kativu, 2023). It is native to southern and central African countries including Angola, Namibia, Botswana, Zambia, South Africa and Zimbabwe. It is a robust species, with broad leaves which appear bluish-green (glaucous) in colour (Figure 1). Its flowers typically possess long pedicels arranged spirally on the peduncle. The species can grow up to 120 cm tall, emerging from a brown bulb approximately 3-6 cm in diameter (Stedje and Kativu, 2023). It inhabits wet, sandy, or clay soils, often around pans, in grassy depressions, and along roadsides, particularly in areas without shade trees.

The bulbs and leaves of *D. glaucum* are reported to be edible (Al-Najjar, 2020; Welcome and Van Wyk, 2019; Peters *et al.*, 1992, Fox and Young, 1982). The young leaves are commonly eaten fresh or can be combined with other foods, such as the corms of *Eulophia speciosa*, and cooked (Leffers, 2003). However, this species has also been documented to be toxic to cattle, goats and sheep (Watt and Breyer-Brandwijk, 1962; Obermeyer, 1964; Leffers, 2003; Botha and Penrith, 2008; Vogel *at al*., 2023).

Figure 1. Image of *Dipcadi glaucum* in fruit.

In South Africa, the plant is known locally as *malkopui*, an Afrikaans name that translates to "mad-head-onion." (Vogel *et al*, 2023). While several studies report toxicity, the specific toxin and its mechanism of action remain unknown. Cardiac-glycosides which are typically responsible for such toxic effects, have not been detected in this species (Botha and Penrith, 2008). Toxicity may also be variable and may depend on growth stage and habitat conditions. According to Botha and Penrith (2008) consumption of this species by ruminants induces disorientation and eventually posterior paresis in cattle, starting with knuckling over of the fetlocks, causing them to stumble. Sheep are more frequently poisoned than cattle, and, in addition often develop severe diarrhoea and fever, and pregnant ewes may abort.

A plant's biological activity is determined by its phytochemical constituents. Phytochemicals are a diverse group of bioactive compounds synthesized by plants, primarily as part of their secondary metabolism (Kaushik *et al.*, 2021). These compounds, which include flavonoids, alkaloids, terpenoids, phenolics, and glycosides, play a crucial role in plant defense mechanisms as well as in the colors, flavors, and scents of various plant foods. One notable aspect of phytochemicals is their cytotoxicity, which plants use to inhibit the growth or survival of other organisms (Indhumathy, 2023). The cytotoxic nature of certain phytochemicals, while beneficial in small doses, can pose risks when consumed in excess or without proper preparation (Okaiyeto and Oguntibeju, 2021). This duality underscores the need for a deeper understanding of their mechanisms of action, optimal consumption levels, and potential toxicity. Phytochemicals have profound implications for human nutrition and health. Many wild food plants, which are often overlooked in modern diets, are rich sources of phytochemicals (Zhang *et al.*, 2023). These plants have been consumed for generations in traditional diets, valued not only for their nutritional content but also for their health-promoting properties. Studying phytochemicals in wild foods is vital for preserving traditional knowledge, promoting dietary diversity, and uncovering novel bioactive compounds that could serve as the foundation for future therapeutics and functional foods (Zhang *et al.*, 2023).

Absence of comprehensive scientific data on the nutritional content and toxicity of *Dipcadi* species limits their utilisation, yet such information is of paramount importance for promoting dietary diversity and addressing hunger (Stadlmayr *et al*., 2011; Aydin *et al*., 2016). Relatively few studies have examined the nutrient composition and toxicity of *Dipcadi* species. The present study therefore aimed at establishing nutritional composition, phytochemical constituents and cytotoxicity of leaves and bulbs of *D. glaucum,* a rarely used wild edible plant species in Zimbabwe.

MATERIALS AND METHODS

Sample collection and sample preparation

Dipcadi glaucum fresh leaves and bulbs were collected from Chiredzi, Beitbridge, Bulawayo and Victoria Falls in Zimbabwe. The plant's identity was confirmed by a plant taxonomist at the National Herbarium and Botanic Gardens (SRGH), where voucher specimens were deposited. The leaves and bulbs were carefully washed with distilled water to eliminate any dirt, then dried in an oven at 65 °C until they attained a constant weight. Dried leaves and bulbs were finely powdered using a grinder. The samples were later stored in airtight containers prior to analysis. Sample material was subsequently analysed for proximate, mineral content, phytochemical composition and cytotoxicity.

Proximate analysis

The proximate analysis followed the guidelines by the Association of Official Analytical Chemists (AOAC, 2000). The following were analysed: moisture content of the dried sample, crude fibre, crude fat, crude protein and ash content; additionally, the available carbohydrates and energy value were calculated.

The moisture content was determined using the oven-drying method (AOAC, 2000). Two grams each of the ground leaf and bulb samples were transferred to a pre-weighed beaker. The samples were dried at a temperature of 105 ± 5 °C in an oven for approximately 2 hours and cooled in a desiccator. Once cooled, the beakers were weighed to obtain the dry weight of the samples. Drying, cooling and weighing of samples were repeated until constant weight was obtained. The moisture content was calculated using the formula:

Moisture (%) = {(W1-W2)/W1}x100

Where W1is weight of original sample, W2 weight of dried sample.

Crude fibre content was determined following the method by Boussama *et al*. (1999). Approximately 1 g of the ground sample was weighed into beaker. To this, 1.25 % sulphuric acid was slowly added to make a total volume of 150 ml. The mixture was then boiled for approximately 30 minutes and subsequently filtered using a vacuum pump to remove the sulphuric acid. The residue was washed three times with 30 ml hot deionized water. Next the residue was washed with 150 ml of preheated 1.25% potassium hydroxide (KOH) and filtered through a porcelain filter. The filtered sample was dried at 105 °C until a constant weight was achieved. After drying, the sample was pre-ashed and then ashed at 550ºC in a muffle furnace. The crude fibre was calculated as percent loss in weight on ashing.

The crude fat content was determined following Association of Official Analytical Chemists (AOAC) method (AOAC, 2000). For this, 3 g of the sample was extracted with petroleum ether using Soxhlet apparatus for about 6 hr. The extracted fat was dried in a rotary evaporator and then weighed.

Crude protein was determined using the Kjeldahl method (Chang, 1998). One (1) g each of the leaf and bulb sample was digested in 20 ml concentrated sulphuric acid and Kjeldhal catalyst. The nitrogen content was converted to protein by multiplying by a factor of 6.25 (AOAC, 2000).

The ash content was determined by weighing out 8 grams of powdered, dried sample into a porcelain crucible. The sample was then ashed for 6 hours at 550 °C in a muffle furnace. The resulting ash was cooled in a desiccator and reweighed. The percentage ash content in the sample was calculated using the formula:

Ash (%) = (Weight of ash / Weight of sample taken) × 100

The percentage of carbohydrates in the sample (Nitrogen Free Extract or NFE) was obtained by subtracting from 100 the total values of the sample's ash, moisture, crude fat, crude protein and crude fibre.

The sample's caloric value was calculated using the carbohydrate, fat and protein contents. The sum of protein and carbohydrates (NFE) was multiplied by 4.3, and separately, the crude fat content was multiplied by 9.1. The resulting sum represents the kilocalories (Kcal) per 100 grams of the sample (Shad *et al*., 2013).

Mineral analysis

Calcium and phosphorus were determined using an atomic absorption spectrophotometer (AAS-Perkin Elmer, Model Analyst 800, USA). The samples were prepared and analysed as follows: 10 g of sample was

weighed. The sample was digested using wet ashing method. A mixture of concentrated nitric acid (HNO_3) was added to the sample in a digestion flask and then heated until the organic matter was completely oxidized when the solution turned clear. After digestion, the solution was cooled and then diluted to the 100 ml mark with distilled water. Working standards for calcium and phosphorus were prepared by serial dilution from a 1000 ppm stock solution of each element. Standard solutions were prepared at various concentrations (0, 1, 5, 10, 20 ppm for calibration). The atomic absorption spectrophotometer (AAS) was calibrated using the prepared working standards. The specific wavelengths for calcium (422.7 nm) and phosphorus (approximately 460 nm) were set according to the manufacturer's guidelines. The diluted sample solutions were aspirated into the AAS. The absorbance of each sample was measured and recorded. The concentrations of calcium and phosphorus in the samples were calculated by comparing their absorbance values to the calibration curve derived from the working standards.

Qualitative Analysis of Phytochemical Constituents

Crude extraction

Phytochemical extraction was carried out at room temperature following the cold maceration extraction method (Tiwari *et al*., 2011). Two solvents, water and analytical grade methanol were used to extract the phytochemicals. The ground leaf and bulb samples were individually added to the solvents at a ratio of 1:10 (w/v) with 100 g of dried leaf and bulb samples each added to 1 litre of solvent. The mixture was gently mixed and left for 48 hours with constant agitation using a shaker. The resulting extracts were filtered using Whatman No.1 filter paper in a Buchner vacuum filter. Using a rotary evaporator, the filtrate was concentrated to a powder at 50 °C, and refrigerated at 4 °C.

Phytochemical screening

Phytochemical screening was conducted using standard qualitative methods (Tiwari *et al*., 2011). The following tests were carried out on the bulb and leaf extracts:

a) Determination of terpenoids. The presence of terpenoids was tested using the Salkowski test. To 3 ml of the extract, 1 ml of chloroform, followed by a few drops of concentrated sulphuric acid were carefully added along the sides of the test tubes. The formation of a reddish brown precipitate indicated the presence of terpenoids.
b) Determination of flavonoids. To 3 ml of extract, 1 ml of 10% ammonia and 1 ml of concentrated sulphuric acid were added. The disappearance of the yellow colour indicated the presence of flavonoids.
c) Determination of saponins (Froth Test): To 3ml of extract in a test tube, 2 ml of distilled water was added. The mixture was vigorously shaken followed by addition of a few drops of olive oil. The formation of a stable foam was taken as an indication for the presence of saponins.
d) Determination of tannin (Ferric Chloride Test). A few drops of 10% ferric chloride were added to 3 ml of extract. The formation of a blue or green precipitate indicated the presence of tannins
e) Determination of alkaloids (Mayer's Test). A few drops of Mayer's reagent were added to 1 mL of extract. A yellowish or white precipitate was formed, indicating the presence of alkaloids.
f) Determination of steroid (Liebermann Burchard Reaction). To 3 ml of the extract, 1 ml of chloroform was added followed by a few drops of concentrated sulphuric acid along the sides of the test tubes. The formation of a reddish brown precipitate at the bottom of the test tubes indicated the presence of steroids.

The brine shrimp lethality assay

The brine shrimp lethality assay (Meyer *et al.*, 1982) was used to evaluate the cytotoxicity of *Dipcadi* leaves and bulbs. Artificial sea water was prepared by dissolving 12 grams of sodium chloride in one litre of distilled water and slowly adding 40% sodium hydroxide until the pH was 8.5. Two grams of brine shrimp (*Artemia saligna*) eggs were then added to 1 litre of the saline water in a beaker. The eggs were exposed to bright light for 24 hours with continuous aeration using an aquarium pump, during which time they developed and hatched into nauplii.

Dimethyl sulfoxide (DMSO) was used to prepare extract concentrations of 0.01 mg/ml, 1 mg/ml, and 100 mg/ml, respectively. Using pipettes, ten brine shrimp nauplii were selected and transferred to sample

vials. The volume was then adjusted to 5 ml using saline water. A drop of yeast cell suspension was introduced as feed for the growing shrimps. These tests were run in triplicate. The positive and negative controls were potassium dichromate (5 mg/ml) and 1% DMSO and saline water, respectively. The vials were kept under light conditions for 24 hours after which the surviving shrimp were counted using a magnifying lens. The mean mortality at each dose level of the extract was then calculated.

Data analysis

Data were compiled in Microsoft Excel 2016. The lethal concentrations of brine shrimp that resulted in 50% death (LD50) were determined using Probit analysis (Pum, 2019).

RESULTS AND DISCUSSION

Proximate analysis

The proximate analysis of *Dipcadi glaucum* (Table 1) revealed significant nutritional insights when compared to staple foods, common vegetables and other wild vegetables. *D. glaucum* was found to contain lower carbohydrate levels, with 35.55% in leaves and 43% in bulbs, compared to major Zimbabwean staple foods. These staples include *Zea mays* (maize, 72.8-75.39%), *Oryza sativa* (white rice, 75.61-80.6%), *Sorghum bicolor* (sorghum, 73.4-75.86%), *Pennisetum glaucum* (millet, 71.4-75.39%), and *Eleusine coracana (*rapoko, 75.7%) as reported by Chitsiku (1989) and Abdulrahman and Omoniyi (2016). The carbohydrate levels in *D. glaucum were* also lower than those reported for common vegetables such as cabbage (56.18%), onion (49.81), coriander (49.65) and spinach (44.58) as documented by Khan *et al*. (2013). Similarly, *D. glaucum* contained lower carbohydrate levels compared to certain wild vegetables commonly consumed in Zimbabwe, including *Amaranthus hybridus* (52.18%) and *Cleome gynandra* (37.06%) as reported by Akubugwo *et al*. (2007) and Kayitesi and Moyo (2022), respectively. However, it exhibited higher carbohydrate levels than *Tagetes minuta* (14.09%) as reported by Opondo *et al*. (2023) and *Corchorus olitorius* (19.56%) as noted by Idirs *et al*. (2020). The proximate analysis of *D. glaucum* highlights its lower carbohydrate content relative to both staple foods and common vegetables, suggesting its potential as a low-carbohydrate dietary option. While it contains fewer carbohydrates than most traditional crops, it still holds some advantages over certain wild vegetables with even lower carbohydrate content, making it a versatile addition to the diet.

Table 1. Proximate analysis of dry weight material of *Dipcadi glaucum* leaves and tubers.

Description	Leaves	Bulbs
Crude Fibre (%)	2.60	5.00
Ether Extract (Crude fat) (%)	5.00	2.50
Calcium(%)	8.52	5.01
Crude Protein (%)	22.60	24.00
Phosphorus (%)	1.63	0.73
Moisture (%)	8.00	11.50
Ash (%)	26.25	14.00
Carbohydrates (%)	35.55	43.00
Energy (K Calories/100g)	295.55	310.85

The crude protein content of *D. glaucum* was notably high with 26.6% in the leaves and 24% in the bulb. This is significantly higher than those of common Zimbabwean staple foods such as maize (8.58-9.5%), white rice (6.8-10.49%), sorghum (10.13-10.7%), and millet (11.03-12.4%), as reported by Chitsiku (1989) and Abdulrahman and Omoniyi (2016). When compared to common vegetables, *D. glaucum* also exhibits higher crude protein content surpassing coriander (18.36%), spinach (17.29%), cabbage (9.59%) and onion (5.01%) as documented by Khan *et al.* (2013). Furthermore, among wild vegetables, *D.glaucum* had higher protein content than *Cleome gynandra* (7.33%), *Amaranthus hybridus* (17.92%) (Akubugwo *et al*., 2007), *Tagetes minuta* (12%) (Opondo *et al.*, 2023) and *Corchorus olitorius* (12.54%) (Idirs *et al*., 2020). The high crude protein levels in *D. glaucum* make it a promising candidate for addressing food security challenges, especially in regions where access to traditional protein-rich foods is limited.

The crude fat content in *D. glaucum* was 5.0% in leaves and 2.5% in bulbs. This crude fat content is comparably higher than the figures reported by Chitsiku (1989) and Abdulrahman and Omoniyi (2016). for staples such as maize (2.85-3.7%), millet (2.56-4.9%), and sorghum (2.70-3.2%) indicating that it can be a supplementary source of fat. When compared to other common staple foods, *D. glaucum* has much higher fat content compared to white rice (0.6%) When comparing *D. glaucum* with common vegetables, the fat content is significantly higher. For example cabbage and onion have almost negligible fat content of 0.1%, spinach has 0.39% with approximately 05.% fat in coriander (Opazo-Navarrete *et al*., 2021). Among wild vegetables, *D.glaucum* has a fat content that is higher than that of species like *Amaranthus hybridus* (4.65%) and *Cleome gynandra* (2.56%) (Akubugwo *et al*., 2007), but lower than *Tagetes minuta* (28.17%) and *Corchorus olitorius* (11.99%), (Opondo *et al.*, 2023; Idirs *et al.*, 2020). The fat content of *T. minuta* appears unusually high and its accuracy has been questioned in a number of studies (Opondo *et al.*, 2023). The crude fat content of *D. glaucum* is higher than many common staples and vegetables, suggesting it could play a role in supplementing dietary fat intake. Although its fat content is lower than some wild vegetables like *T. minuta*, it still offers a relatively rich fat source, making it a valuable addition to a balanced diet.

The calorific values of *D. glaucum* are 295.6 kcal/100 g in the leaves and 310.9 kcal/100 g in the bulbs. These values place *D. glaucum* between vegetables like cabbage (281.23 kcal/100g) and common staple foods like rice (357.4 kcal/100 g) (Chitsiku, 1989) indicating that *D. glaucum* may serve as a moderately high energy source. *D. glaucum* energy values are additionally higher than those of common wild vegetables like *Amaranthus hybridus* (268.92 kcal/100g), *Cleome gynandra* (152.88 kcal/100g) and *Corchorus olitorius* (200.78 kcal/100g).

The ash values obtained for *D. glaucum* are significantly higher, with 26.25% in leaves and 14.0% in bulbs, compared to common staple foods ranging from 0.81-1.16% in maize to 1.67% in millet (Abdulrahman and Omoniyi 2016). The high ash content in *D. glaucum* suggests that it is valuable source of nutrients. Ash content provides a general indication of the mineral richness of food and this normally impacts the taste, texture and stability of the food. In the present study, high contents of calcium (8.52% in leaves and 5.01% in bulbs) and phosphorus (1.63% in leaves and 0.73% in bulbs) were observed, which are much higher than those found in common staple foods ranging from 0.1% in rice to 0.55% in millet (Chitsiku, 1989). These elevated mineral levels in *D. glaucum* highlight its potential as an excellent dietary source of calcium and phosphorus. Ash content in the wild vegetables is lower than that of *D. glaucum* ranging from 5.85 in *Cleome gynandra* to 13.80 in *Amaranthus hybridus* (Akubugwo *et al*., 2007; Opondo *et al.*, 2023; Idirs *et al.*, 2020). Wild vegetables are well known for their diverse mineral profiles and *D.glaucum* out-performs most in terms of ash and mineral content.

The crude fibre values for *D. glaucum* were 2.6% in leaves and 5.0% in bulbs. These values fall within the range of those of common staple foods, which range from 3.19% in millet to 10% in rapoko (Chitsiku, 1989). This suggests that *D. glaucum* is relatively low in crude fiber compared to some staple foods, particularly those with higher fiber content like rapoko. However, the values obtained for *D. glaucum* are lower than those obtained for vegetable such as onion (19.53%), cabbage (10.36%), spinach (24.08%) and coriander (23.30%). This could imply that *D. glaucum* is less fibrous and could be easier to digest compared to these vegetables. Wild vegetables such as *Amaranthus hybridus*, *Cleome gynandra* and *Corchorus olitorius* have crude fibre values ranging from 7.58 to 8.61%. Dhingra *et al*. (2012) reported that the values of crude fibre show the amount of indigestible plant material in a food, primarily the compounds cellulose, hemicellulose and lignin. Such material provides several health benefits such as improved digestion and reduced risk of chronic diseases like diabetes.

Phytochemical Screening

D. glaucum is rich in a variety of phytochemicals that offer both health benefits and sensory contributions to food. Table 2 indicates the presence of alkaloids, tannins, flavonoids, and terpenoids in both leaves and bulb extracts. Steroids and saponins only tested positive in the bulb and leaves, respectively. The phytochemical compounds observed are similar to

those found in other *Dipcadi* species, such as *Dipcadi serotinum* (L.) Medic. (Adly *et al*., 2015) and *Dipcadi erythraeum* Webb & Berthel. (Al-Najjar, 2020). The flavonoids and tannins observed in *D. glaucum* are known antioxidants (Suffredini *et al*., 2004). Antioxidants protect cells from damage by free radicals that form during oxidative processes in metabolism (Altemimi *et al*., 2017).

Table 2. Phytochemical assay results of data of *Dipcadi glaucum* crude aqueous extracts.

Phytochemical	Bulb Water	Leaf Water
Saponins	-	+
Alkaloids	+	+
Tannins	+	+
Flavonoids	+	+
Steroids	+	-
Terpenoids	+	+

Flavonoids help give vibrant colours to many fruits, vegetables, and flowers, enhancing their visual appeal. Additionally, they influence the flavour of foods, impacting sweetness, bitterness, and other taste profiles. Alkaloids are a large and diverse group of phytochemicals that are commonly associated with toxicity and medicinal properties of plants (Cushnie *et al*., 2014). When present in high concentrations exceeding 20 mg per 100 g, they have been found to be harmful causing neurological disorders and gastrointestinal issues in humans (Chidzwondo *et al*., 2023). Alkaloids often impart a bitter taste to foods, which can influence their sensory appeal and help deter pests. Steroids lower blood cholesterol levels (Li *et al*., 2022) and are also reported to have anti-tumor, immuno-suppressive, hepatoprotective, anti-bacterial, sex hormone, anti-helminthic, cytotoxic and cardiotonic activity (Yadav and Agarwala, 2011). Saponins contribute to stability and texture in food and also offer health benefits by lowering cholesterol levels and having antioxidant and anti-inflammatory activities (Cushnie *et al.*, 2014). Lastly, terpenoids are responsible for taste and aroma in food substances (Masyita *et al*., 2022). Their presence additionally offers the following health benefits to humans: anti-inflammatory, anti-oxidant, anti-microbial, anti-hyperglycemic, anti-fungal and antiviral properties (Fan *et al*., 2023).

Brine shrimp lethality assay

The Brine shrimp lethality test is a fast, easy and cheap method used to assess cytotoxicity in plants. In the present study, mortality was 100% in the potassium dichromate standard positive control and 2% in the DMSO and saline water negative controls. Accordingly, the mean mortalities shown in Table 4 have been reduced by 2% to adjust for background mortality observed in the negative controls. The assay showed that the mortality of the brine shrimp increased with higher concentrations of the extract. Toxicity was also observed to be higher in the methanol extracts when compared to the aqueous extracts. This result is consistent with findings from similar studies (Turkmen *et al*., 2006). The quantity and composition of phytochemicals in the extract depends on the solvent used. Methanol is less polar than water and therefore dissolves a broader range of phytochemicals including both polar and non-polar compounds. In contrast the more polar water exclusively dissolves polar compounds (Altemimi *et al*., 2017).

Results from the regression analysis of the brine shrimp mortality rates showed that the lethal concentration required to kill 50% shrimps (LC50 values) were least in the methanol bulb extract (2.72 mg/ml) and highest in the aqueous bulb extract (1949.85 mg/ml). According to the standard brine shrimp lethality bioassay criteria, an LC50 value less than 1000 µg/ml (or 1 mg/ml) is considered bioactive in toxicity evaluation of plant extracts (Meyer *et al*., 1982). Given that the LC50 values for both extracts of *D. glaucum* are significantly higher (Table 3) than this threshold (2.72 mg/ml for methanol and 1949.85 mg/ml for aqueous), the results indicate that *D. glaucum* appears to be non-toxic based on this assay using the brine shrimp. The brine shrimp assay is a simple, inexpensive screening test for cytotoxic or pharmacologically active constituents, but it is unable to detect compounds requiring metabolic activation in animals or humans. Allison (1978) gave an example of *Amaranthus* species that are known to contain nitrate, which is relatively non-toxic, but its conversion to nitrite by micro-organisms in the rumen results in toxicity to animals.

Table 3. Mean mortality of *Artemia saligna* nauplii at different concentrations of four *Dipcadi glaucum* extracts and their LC_{50}.

Sample	Percent mean mortality (%) with standard deviation (SD)						LC_{50} (mg/ml)	
	100mg/ml	SD	1mg/ml	SD	0.01mg/ml	SD		SD
Leaf water extract	35	1	20	2	0	0	64.34	1.6
Leaf methanol extract	60	2	30	3.5	20	1	22.80	0.8
Bulb aqueous extract	5	2	0	0	0	0	1949.85	7.7
Bulb methanol extract	60	3	55	1.5	25	3	2.72	0.6

While *D. glaucum* appears to be non-toxic using the brine shrimp assay, further research is required to assess its safety in other species including humans and at higher concentrations. Advanced cytotoxicity models, such as mammalian cell cultures or in vivo systems, are recommended to confirm these findings. Recent reports from South Africa indicate possible toxicity to ruminants (Vogel *et al*., 2023), showing that toxicity may differ across species and environments. Moreover, the presence of the various phytochemicals identified in the present study such as alkaloids, saponins, tannins, and terpenoids in *D. glaucum*, may be cytotoxic at higher concentrations.

CONCLUSIONS

The results from this study show that *Dipcadi glaucum* leaves and bulbs contain a variety of nutrients, minerals, and phytochemicals that are of benefit to human health. However, further research is needed to assess its safety for human consumption, especially concerning its phytochemical composition and potential toxicity across different species. Proximate analysis results show that some of the nutrients are present in quantities comparable to the common staple foods. The protein content of the plant is higher than in the common staple foods and this is an important result showing a huge potential of this plant in supplying an often limited nutrient to diets especially in poor rural communities. The high ash content indicates the presence of a variety of mineral elements, highlighting the plant's potential as a valuable dietary source of these essential nutrients. The cytotoxicity studies show that the *D. glaucum* leaves and bulbs are non-toxic using the brine shrimp assay. However, reports from South Africa suggesting possible toxicity warrant further studies to determine if the toxicity of *D. glaucum* could vary according to habitat conditions or other factors.

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