Original Research Article

Assessment of the Nutritional Value of *Scolopia mundii* Fruits, A Southern African Edible Wild Fruit

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| **ABSTRACT**  **Introduction:** In many rural communities across Southern Africa, wild edible fruits play a critical role in supplementing diets and enhancing food and nutrition security. Despite their potential, several indigenous species remain underutilised and undervalued in formal nutrition programmes. *Scolopia mundii (S. mundii)*, is one such wild fruit widely consumed in rural communities in Lesotho where it grows, however, very little is known about its nutritional value.  **Aim:** The aim of the study was to determine the nutrient and phytochemical composition *S. mundii* fruits so as to assess their potential as a supplementary nutritional source that could alleviate micronutrient deficiencies and food insecurity, which are prevalent among children in rural communities in Lesotho.  **Methodology:** Fresh ripe fruits of *S. mundii* were collected and subjected to qualitative and quantitative phytochemical screening, proximate nutritional analysis, mineral profiling, and selected anti-nutrient analysis. Standard methods were used for nutrients content (e.g., AOAC for proximate composition), phytochemical quantification (e.g., Harborne, Folin-Ciocalteu), and mineral analysis using ICP-AES  **Results and Discussion:** The fruits were found to contain significant amounts of macronutrients and micronutrients. Some notable values included vitamin C (1.21 ± 0.43 g/100g), carbohydrates (3.14 ± 0.30 g/100g), protein (2.10 ± 0.02 g/100g), dietary fibre (3.54 ± 0.25 g/100g), and fat (0.50 ± 0.02 g/100g). The mineral analysis revealed high levels of essential elements; calcium (4.295 mg/100g), magnesium (6.042 mg/100g), and manganese (2.228 mg/100g). Phytochemicals such as phenolics (92.36 ± 5.42 mg/kg), saponins (178.13 ± 4.52  mg/kg), tannins (58.60 ± 8.21 mg/kg), and alkaloids (17.70 ± 0.15 mg/kg were present. Some anti-nutritional components, such as oxalates (138.90 ± 15.03 mg/kg) and phytates (5.64 ± 0.74 mg/kg) were also detected, but were within acceptable levels.  **Conclusion:** *S. mundii* fruits contain a range of essential nutrients and phytochemicals, which make them potentially valuable nutritional resource. These fruits could add to dietary diversity and act as a food security coping strategy in poor rural communities of the nation. The promotion of their consumption may also help address the negative perceptions about wild foods and improve health outcomes among poor rural populations. |

*Keywords: Scolopia mundii*; phytochemicals; nutrients, edible; wild; fruits

1. INTRODUCTION

Wild edible fruit and vegetables are an important source of nutrition for many rural communities in most developing countries. Many people in rural communities worldwide still depend on indigenous wild edible fruits and vegetables for food and income (Cavender, 2006; Nxusani, et al., 2023).

In many indigenous rural communities of sub-Saharan Africa, wild edible fruits and vegetables are an important source of nutrition, food security and economic livelihood and have cultural significance as well (Omotayo & Aremu, 2020; Lyamuya et al, 2023; Gumoshabe et al, 2023). According to the United Nations, (FAO, 2003) fruits and vegetables are important components of a balanced, healthy diet, because they generally contain high amounts of vitamins, minerals, micronutrients, fibre, and important phytochemicals that are essential in maintaining good health, while being low in carbohydrates, hence the United Nations has long recognised the contribution of edible wild fruits and vegetables to food and nutritional security of indigenous peoples throughout the world (FAO, 2016).

Lesotho, like many countries in sub-Saharan Africa, has an abundance of wild edible fruit and vegetable species (Bvenura & Sivakumar, 2017), yet the region has the lowest consumption of fruits and vegetables; below the WHO recommended daily average (Sarfo et al, 2023; Stadlmayr et al, 2023), because of the lukewarm attitude towards consumption of indigenous edible wild fruits and vegetables among communities, especially in urban areas. The consumption of edible wild fruits and vegetables is usually very low in urban communities due to their non-availability, non-accessibility, and non-desirability (Harris et al, 2021). Furthermore, in some urban communities, wild fruits and vegetables are considered as poverty foods and therefore, their consumption is often associated with rural life (Mbenyane, 2017; Ntlanga et al, 2023). Due to these perceptions, edible wild fruits and vegetables, are hardly considered in national and international food security policy discussions (Shaheen et al, 2017) and their nutritional benefits remain underutilised or untapped (Moteetee, et al, 2019). The fruits of *S. mundii* are one of these wild edible fruits whose nutritional value remains untapped.

*S. mundii* is a wild berry fruit tree of the Salicaceae, and is widely distributed in the southern African sub-region, mainly in Eswatini, Lesotho, South, Africa, and Zimbabwe (Burring, 2005). The local (Sesotho) name is *qhoqolosi* and some of its other common English names include mountain saffron, and red pear (Roux, 2003). The habitat of *S. mundii* is rocky the hillside forest margins from where it spreads laterally along the foot of the cliffs and downward along streams and river banks. At the collection area at Ha Mamathe, the plant occurs on hilly slopes from an elevation of 30 m up to 2000 m above sea level. The *S. mundii* plant flowers in spring (May - August) with small greenish white flowers developing into green fruits which then turn yellow or orange as they mature. The fruits of *S. mundii* are smooth, globose and contain an average of two seeds. Maturation of the fruits takes three to four months (October - January) during this time, they turn from green to orange yellow and to reddish orange when ripe fully ripe (Sun Trees, 2018). Onharvesting, the fruits become reddish-brown and are said to be ready for consumption (Fig.1).

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| http://www.plantzafrica.com/plantqrs/plimagesqrs/scolopiaflow.jpg  a - flowering | http://www.plantzafrica.com/plantcd/plimagescd/dovyalisrhamnoides_unripe.jpg  b. green fruits | c. ripening fruit | d. fully ripened fruit |

Fig. 1 Fruits of *S. mundii* at different stages of development

*Source: Jan Burring, SANBI Scolopia mundii, (Eckl. & Zeyh.) Warb. SA Tree No. 496,* Kirstenbosch ***National Botanical Garden, August 2005. PlantZAfrica.com***

The health and well-being, and household economy of many rural population worldwide are intrinsically linked to the biological biodiversity of their physical environments (Teklehaimanot, Chivian, 2008). Wild fruits are a very vital source of vitamins, minerals, dietary fibres, and, phytochemicals that have many medicinal properties but are underutilised. This is either due to lack of information of their nutritional value, accessibility, or unacceptability by the communities where these plants grow (Bvenura & Sivakumar, 2017). The use of wild edible vegetables and fruits in medicinal preparations emphasises their importance beyond nutrition, and thus, highlighting their function in pharmacology and ethnomedicine (Pullaiah et al. 2017; Van Wyk, 2017). Given this context, and the fact that food and nutrition security remain a challenge for many developing countries (Berry et al, 2015), the need for a comprehensive study of these edible wild fruits to determine their nutritional and nutraceutical value cannot be overemphasized. Such information would aid efforts by governments to promote their consumption and incentivise their cultivation where possible to combat malnutrition, developing functional foods and pharmaceuticals, and ensuring food security (Bvenura & Sivakumar, 2017; González-Zamorano et al, 2025).

As an edible wild fruit in rural Lesotho, *S. mundii* could play a role in alleviating micronutrient deficiency in rural households, especially among children under five years (WHO, 2020; Gaston et al, 2022). However, in order for these edible wild fruits to be recognised as valuable sources of nutrients and hence promote their consumption and incorporation in the diet of rural households, adequate scientific information on their nutritional value is essential. During this study, our search did not yield any literature on the nutrient content of *S. mundii* fruits. The available literature was on its taxonomy, ecology, habitat, distribution, morphology, and ethnobotany (Burring, 2005; Germishuizen et al, 2006). The aim of this current study was to determine the nutrient composition of *S. mundii* fruit and their potential as a cheap, nutritious food supplement

# 2. Materials and Methods

**2.1 Sample collection and preparation**

Ripe fruits of *S. mundii* were collected at the outskirts of Ha Mamathe village, which is about 40 km north of the capital Maseru, with the geographical coordinates, latitude -29.13 S and longitude 27.84 E, at an elevation of 1,683 metres above sea level. The *S. mundii* fruits were collected in December when they were in season from an area, of about 1.5 hectares along rocky hillside forest margins near a stream south of the village. Due difficult accessibility caused by the mountainous terrain, fruits were collected from two locations within the 1.5 hectre area; this being the area where the ripe fruits were found on average from five plants in each location. The *S. mundii* plant is well distributed in this area and is consumed by most of the village inhabitants, especially shepherd boys when they take their cattle for grazing and spend days to weeks in the field (Pawlos et al, 2021). The collected samples were combined produce a composite sample. The fruits were collected in and transported to the laboratory on the same day of collection and stored at 4oC to prevent loss of moisture. The plant species was authenticated at the National University of Lesotho Herbarium. The fruits were washed clean with tap water, rinsed with distilled water, and air dried at room temperature. A 10 g portion of the dried fruits was weighed out for the determination of moisture content. A second 10 g portion of the dried fruits was ground to into and used to prepare an aqueous extract by infusion at room temperature in 200 mL distilled water for 24 hours with continuous shaking using a on a benchtop shaker (Labotec, Model No. 202) and filtered through Whatman filter paper No. 50 (24.0 cm). The mixture was centrifuged at 4500 rpm for 15 min (Sorescu, et al, 2017). The crude aqueous extract was then filtered under vacuum and stored at 4oC until needed for the various tests and analyses.

**2.2 Qualitative screening for phytochemicals**

The preliminary qualitative screening of the phytochemicals was carried out using standard methods as described in the literature (Nortjie et al, 2022, Trease & Evans, 1989).

**2.2.1 Detection of alkaloids**

The aqueous extract was mixed with dilute HCl and filtered, and the filtrate used in the following tests).

**Mayer’s Test:** The filtrate was treated with Mayer’s reagent (potassium mercuric iodide HgI2). The formation of a yellow-coloured precipitate indicates the presence of alkaloids.

**Wagner’s Test:** The filtrate was treated with Wagner’s reagent (iodine in potassium iodide). The formation of a brown/reddish precipitate indicates the presence of alkaloids

**Dragendorff’s test:** 1 mL of Dragendorff”s reagent (a mixture of basic bismuth nitrate 4BiNO3(OH)2, BiO(OH) and potassium iodide, KI dissolved in diluted acid acetic or tartaric acid) is added to 2 mL of extract, an orange red precipitate was formed, indicating the presence of alkaloids.

**2.2.2 Detection of flavonoids**

**Lead acetate test:** A few drops of lead acetate solution is added to 0.5 mL of extracts. The formation of a yellow-colour precipitate indicates the presence of flavonoids.

**Sulphuric acid test:** A few drops of dilute sulphuric acid are added to the extracts, and the formation of orange colour indicates the presence of flavonoids.

**Sodium hydroxide test:** 5 mL of 10% sodium hydroxide solution was added to an equal volume of the aqueous extracts of *S. mundii* fruit. A yellow solution indicates the presence of flavonoids.

**Ferric chloride test:** 2 mL portion of the fruit extract was diluted with distilled water in the ratio of 4:1 and a few drops of a 10-percent solution of iron (III) chloride, FeCl3 was added. A green or blue solution indicates the presence of flavonoids.

**2.2.3 Detection of phenolic compounds**

**Ferric chloride test:** A few drops of ferric chloride are added to 10 mL of fruit extract. A bluish-black colour indicates the presence of phenolic compounds.

**Lead acetate test:** A few drops of lead acetate solution is mixed with 10 mg fruit extract. A brown precipitate indicates the presence of phenolic compounds.

**2.2.4 Detection of saponins**

In the qualitative screening for saponins 5.0 mL of distilled water was mixed with 1.0 mL aqueous crude fruit extract in a test tube and it was shaken vigorously. The froth formed was mixed with few drops of olive oil and again shaken vigorously and a foamy appearance indicated the presence of saponins (Soforowa, 2005).

**2.2.5 Detection of tannins**

To 2 ml of the extract is mixed with 1mL of distilled water and heated. The mixture is filtered and 2 mL of 5% iron (III) chloride, FeCl3 was added to the filtrate. The appearance of a dark-blue or dark-green colour indicated the presence of tannins.

**2.2.6 Detection of terpenoids**

**Salkowski’s Test:** 5 mL of the aqueous fruit extract was mixed with 2 ml chloroform and 3 ml concentrated H2SO4 was carefully added to form a layer. A reddish-brown coloration of the interface was formed indicating the presence of terpenoids.

**2.2.7 Detection of proteins**

**Biuret test.** Two drops of 3% copper sulphate and few drops of 10% sodium hydroxide were added to 1 mL of the aqueous fruit extract, a violet or red colour formation indicated the presence of proteins.

**Ninhydrin test.** Two drops of 0.2% freshly prepared ninhydrin solution added to 1 mL of fruit extract. The formation of a purple colour indicates the presence of proteins.

**2.2.8 Test for carbohydrates**

**Molish test:** A few drops of α-naphthol prepared in ethanol solution were added to 2 mL of fruit extract, followed by addition of a few drops of concentrated H2SO4 along the walls of test tube. At the junction of two liquids, a violet-coloured ring appeared, indicating that carbohydrates were present.

**Benedict’s test:** To 5 mL of Benedict’s reagent, 8-10 drops fruit extract were added, the mixture was then heated for five minutes; the resulting dark red precipitate indicated the presence of carbohydrates.

**Fehling’s test:** To 2 mL of extract, an equal volume of Fehling’s (A & B) solution was added and the mixture heated for five minutes. The resulting red/dark red precipitate indicated the presence of carbohydrates.

**2.2.9 Detection of oxalates**

2.0 mL of the extract was treated with a few drops of glacial acetic and a dark green colouration indicated the presence of oxalates.

**2.2.10 Detection of phytates**

1 mL of aqueous fruit extract was transferred into a clean test tube 1 mL of Wade’s reagent was added and mixed. A reddish pink colour is formed, which fades with time indicates the presence of phytates, If the colour persists it indicates the absence or very low levels of phytates (Fruhbeck, et al. 1995).

**2.3 Quantitative determination of phytochemicals**

**2.3.1 Proximate analysis**

For the quantitative determination of proximate composition of *S. mundii* fruits, moisture was determined by air oven drying (AOAC, 2016) at 105oC to a constant weight, ash was determined by the gravimetric method. The samples were ignited at 550-600 oC to oxidise all organic materials without flaming until a constant weight was obtained (AOAC, 2016). The crude protein content was calculated from the total nitrogen determined by the Kjeldahl method (AOAC, 2016) using the conversion factor of 6.25. Crude dietary fibre was determined by the Wende method and crude fat contents in the fruit samples were analysed using standard methods (AOAC, 2016). Carbohydrates were determined using the method by Ammar (Ammar et al, 2013) and Vitamin C was determined by AOAC method 967.21 (AOAC, 2016). The energy content of the samples was calculated in kilocalories (kcal) based on the Atwater specific factor system, which is a refinement of the Atwater system, food composition factors (4, 9, 4 for protein, fat, carbohydrates) (Merrill & Watts, 1973). The percentage crude protein, crude fat, and crude carbohydrates of the fruits were multiplied by these factors respectively (USDA, 2016; FAO, 2003).

**2.3.2 Determination of alkaloids**

The determination of alkaloids in the *S. mundii* fruit extract was carried out using the method of Harborne (1973). A sample of 1. 5 g of the fresh fruit sample was weighed into a 250 mL beaker and 200 mL of 10% acetic acid in ethanol added. The beaker was covered and allowed to stand for 4 hours. The mixture was then filtered and the extract concentrated on a water-bath to one-quarter of the original volume. Concentrated ammonium hydroxide was added dropwise to the extract until the precipitation was complete. The whole solution was allowed to settle and the precipitate was collected and washed with dilute ammonium hydroxide (2M) and then filtered. The residue (if available), is the alkaloid precipitate which is then dried and weighed.

**2.3.2 Determination of flavonoids**

Flavonoids were determined by the method described by Chang et al (2002). An air-dried fruit sample weighing 10 g was extracted with 100 mL of 80% aqueous ethanol at room for 24 hours. The crude extract was recovered by centrifugation at 27000xg for 20 minutes. The solvent was evaporated off in a vacuum oven at a temperature of 60 ᵒC to obtain dry ethanolic extract.

**2.3.3 Determination of total phenolics**

The total phenolics content of the fruit extract was determined by using a Spectrophotometric method. The reaction mixture was prepared by mixing 0.5 mL of ethanol extract, 2.5 ml of 10% Folin-Ciocalteu’s reagent dissolved in water and 2.5 mL 7.5% NaHCO3. The blank was concomitantly prepared, containing 0.5 mL ethanol, 2.5 mL 10% Folin-Ciocalteu’s reagent dissolved in distilled water and 2.5 mL of 7.5% of NaHCO3. The samples were thereafter incubated in a water bath with a thermostat set at 45oC for 45 min. The absorbance of the incubation mixture was determined using spectrophotometer at λmax = 765 nm. The test samples were prepared in triplicate for each analysis and the mean value of absorbance was obtained. The same procedure was repeated in triplicate for the standard solution of Gallic acid and the calibration line was construed. Based on the measured absorbance, the concentration of phenolics was read (mg/ml) from the calibration line; then the total phenolics content of the fruit extract was expressed in terms of milligrams (mg) of gallic acid equivalents per gram of dry extract (mg of GA/g of dry extract).

**2.3.4 Determination of saponins**

The saponin content of *S. mundii* fruits was determined using the method described by Obadoni and Ochuko (2001). A portion of the air-dried fruit was ground into powder and 20g was put into a conical flask followed by the addition of 100 ml of 20% (v/v) aqueous ethanol. The contents were then heated over a hot water bath for 4 hours with continuous stirring at about 55oC. The mixture was filtered and the residue re – extracted with another 200 mL of 20% (v/v) aqueous ethanol. The combined extracts were reduced to 40 mL over a water bath set at 90ºC. The concentrate was transferred into a 250 mL separatory funnel and 20 mL of diethyl ether added and the mixture shaken vigorously. The aqueous layer was recovered while the ether layer was discarded. The purification process was repeated three times and then 60 mL of n-butanol was added to the combined aqueous layer. The combined n–butanol extracts were washed twice with 10 mL of 5% (w/v) aqueous sodium chloride, NaCl. The extract was the evaporated under vacuum. The remaining solution was heated in a water bath. After evaporation, the samples were dried in the oven (Memmert GmbH UN30) at 30oC to a constant weight. The saponin content was calculated as percentage.

**2.3.5 Determination of tannins**

The tannin content of the *S. mundii* fresh fruit was determined using the method described by Van-Burden and Robinson (1981). A 500 mg portion of the sample was weighed into a 50 ml plastic bottle. 50 mL of distilled water was added and the mixture shaken for 1 hour on a mechanical shaker. The mixture was filtered into a 50 mL volumetric flask and made up to the mark. After that, 5 mL of the filtrate was pipetted out into a test tube and mixed with 2 mL of 0.1M iron (III) chloride, (FeCl3)in 0.1N hydrochloric acid, HCl and 0.008M potassium ferrocyanide, K4[Fe(CN)6]. The absorbance of this mixture was measured at 120nm within 10 minutes using a UV/Vis spectrophotometer (Infitek SP-LUV759).

**2.3.6 Determination of total terpenoid content**

The total terpenoid content of the *S. mundii* fresh fruit was added to 1.0 mL of the aqueous extract of the fruit. The mixture was centrifuged at 5000 rpm for 10 min and left to stand for 3 min, followed by addition of 200 μL of concentrated H2SO4 and incubation of the mixture at room temperature in the dark for 2 hours. After the 2 hour incubation, a reddish-brown precipitate had formed. The precipitate was filtered out and 3.0 mL 95% (v/v) methanol was added to the precipitate and the flask shaken vigorously until the precipitate had completely dissolved. The absorbance of the resulting solution was measured at 538 nm using a UV/Vis spectrophotometer. A calibration curve was generated using 10–100 μg/mL of linalool standard solution (R2 = 0.995). The calibration curve was then used to calculate the dry extract (mg LE/g dried extract).

**2.3.7 Determination of oxalates**

The quantitative determination of the oxalate content of the *S. mundii* fresh fruit was carried out using the precipitation method reported by Ejikeme et al. (2014) and Munro & Bassir (1969). A 2.50 g of the air-dried sample was ground into powder and extracted three times each with 20 mL of 0.3 M HCl by warming heating at 50oC for an hour with constant stirring using a magnetic stirrer. The fruit extract was made alkaline by adding 1.0 mL of 5.0 M (NH4)2OH to 5.0 mL of the extract. This was followed by the addition of 2 drops of phenolphthalein indicator, 3 drops of glacial acetic acid and 1.0 ml of 5% calcium chloride to make the mixture acidic and allowing it to stand for 3 hours and then centrifuged at 3000 rpm for 15 minutes. After discarding the supernatant, the precipitate was washed three times using hot distilled water and mixing thoroughly each time before centrifugation. Then, to each tube, 2.0 mL of 3.0 M H2SO4 was added and the precipitate dissolved by warming in a water bath at 70oC. The solution was titrated with freshly prepared 0.01 M KMnO4, at room temperature until the first pink colour appeared throughout the solution. The solution was allowed to stand until it returned to colourless, after which it was warmed on an electric hot F (Bioevopeak HPS-280) at 70oC for 3 minutes, and re-titrated until a pink colour appeared and persisted for at least 30 seconds.

**2.3.8 Determination of phytates**

The fruits were analysed for their phytate content using the method described by Agostinho et al (2016). Phytic acid (PA) is extracted from grain-based food samples by mixing 0.5 grams of ground material with 20 mL of 0.5 M hydrochloric acid under constant agitation for one hour. The mixture is then centrifuged, and the supernatant filtered. This extract is passed through an anion-exchange resin column to separate PA from inorganic phosphates. Phosphates are eluted with 0.1 M NaCl, while PA is recovered using 10 mL of 0.75 M NaCl. The method relies on the inhibition of a coloured Ca(II)-GBHA complex by PA, providing a simple, sensitive, and selective means of quantification.

**2.3.9 Determination of minerals**

Fresh *S. mundii* fruit samples were prepared for minerals analysis by wet digestion using a mixture of acids; nitric acid, (HNO3), perchloric acid and hydrochloric acid, (HCl), in the ratio of 7:1:4 to completely digest the samples. Quantification was done by Induced Couple Plasma-Atomic Emission Spectrophotometer (Varian ICP-AES Liberty AX model) using a multiple element standard solution.

3. results and discussion

The qualitative analyses the of *S. mundii* fruit extracts yielded positive results in terms of the selected phytochemicals; alkaloids, flavonoids, phenols, saponins, and tannins, terpenoids as well as the antinutrients phytates and oxalates. The results of the qualitative screening of the fruits extract are shown in Table 1.

Table 1. Qualitative phytochemical profile of *S. mundii* fruit extract

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| --- | --- |
| Phytochemicals | Results |
| Flavonoids |  |
| * Alkaline test | +++ |
| * Ferric chloride test | ++ |
| Saponins | + |
| Alkaloids |  |
| * Mayer’s test | + |
| * Wagner’s test | + |
| * Dragendorf’s test | + |
| Tannins | + |
| Total phenolic compounds |  |
| * Ferric chloride test | ++ |
| * Lead acetate test | + |
| Total terpenoids |  |
| * Ferric chloride test | + |
| * Lead acetate test | + |
| Oxalates | + |
| Phytates | + |
| Proteins |  |
| * Biuret’s test | + |
| * Ninhydrin test | + |
| Carbohydrates |  |
| * Molish’s test | + |
| * Benedict’s test | + |
| * Fehling’s test | + |

*Legend:* + *= present;* - *= absent; colour intensity: + = low; ++ = moderate; +++ = high*

Plant secondary metabolites are non-nutritive bioactive phytochemical compounds that are produced by plants as a protective mechanism against viruses, bacteria, fungi and parasites. Though they are non-essential nutrients, these dietary phytochemicals, protect humans against diseases. These biologically active compounds have attracted much interest because of the wide versatility of their applications (Thakur *et* al, 2020) and have been shown to be beneficial to human health too (Santhi & Sengottuvel, 2016, Jaeger & Cuny, 2016).

Phytochemicals provide notable nutritional benefits and considerable economic significance when used in functional foods, non-alcoholic beverages, and various other food products (Srivastavaa et al, 2025). Phenolic compounds are secondary metabolites reported to exhibit anti-inflammatory activity (Biluca et al, 2020), oestrogenic activity, enzyme inhibition, and antimicrobial activity (Moo-Huchin et al, 2015) partly due to their antioxidant capacity (Skrypnik et al, 2019). Phenolic compounds have demonstrated antioxidant activities that are essential for optimal cellular functions (Nemzer et al*,* 2020; Akter et al, 2021). Alkaloids possess potent medicinal qualities such as anti-inflammatory, antimalarial, antimicrobial, and alleviation of spasms (Thakur et al, 2021). The medicinal properties of flavonoids include anti-cancer, antioxidant, antiviral and anti-inflammatory (Zhao et al, 2019; Ullah et al, 2020).

The results of proximate analysis of the *S. mundii* fruit samples are shown in Table 2. In preliminary assessment of the nutritional quality of foods, proximate analysis is usually sufficient to establish the general category of foodstuff to which a particular sample belongs. The determined concentration values of the macronutrients in *S. mundii* fruit samples in this study were within the range reported for other wild edible fruits growing in the Southern African sub-region (Sibiya, 2012).

Table 2. Mean (± SD) proximate composition of *S. mundii* fruits (n=3) and results of similar studies

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| --- | --- | --- | --- | --- |
| Nutrient | *S. mundii*, g/100g | Vijay & Singh, (2024)  *F. indica,* g/100g | Nitcheu et al, (2017)  *(S. spinosa)* | Yimer et al, (2023)  *T. madagascariense*  g/100g |
| Moisture | 7.95±0.85 | 74.2 | 78.8, g/100g | 77.6 – 95.6 |
| Crude protein | 2.1±0.02 | 0.5 | 9.0, g/100g | 6.3 – 21.7 |
| Total carbohydrates | 3.14±0.30 | 24.2 | 28.7, g/100g | 38.1 – 83.0 |
| Crude fat | 0.50±0.02 | 0.53 | 15.8, g/100g | 0.7 - 6.1 |
| Crude fibre | 3.54±0.25 | 12.25 | 9.2, g/100g | 8.9 – 22.3 |
| Vitamin C | 1.21±0.43 | - | - | - |
| Ash  Energy | 5.51±1.0  1585±36 | 0.5  94 | 3.5, g/100g  1681, kJ/100g | 3.5 - 16.4  275 - 371 |

The moisture content, which is the amount of water that plant tissues can hold, is essential for many vital physiological processes and is involved in keeping the plant from dehydration (Lalika et al, 2013). High moisture content in fruits increases in the rate of microbial growth, which can greatly reduce the shelf life of the fruit. The moisture content of the fruits was very low at 7.95 g/100g, which means that the fresh fruits would have a longer shelf life. The fibre content of the fruits was 3.54 g/100g, which indicates that the fruits have a high fibre content. Dietary fibre in whole fruits has many beneficial health effects, which includes promotion of a healthy microbiota ecosystem (Klinder et al, 2016), reducing the risk of obesity, improving gut health, decreasing cardiovascular diseases, reducing the risk of cancers, stroke and type II diabetes (Miller et al, 2017; Dreher, 2018; Veronese et al, 2018). Studies have also linked the intake of fibre-rich foods to the decrease in some diseases like hypertension, coronary heart disease, diabetes, stroke, and some forms of cancer (Ma et al, 2019; Soliman, 2019). Generally, fruits are not considered as good a source of dietary protein. The crude protein content of the fruits was 2.10 g/100g which is within the range for many fruits (USDA, 2016). Proteins not only support growth, but also play important role in the maintenance and repair of body tissues, and in maintaining a healthy immune system (Wolfe, 2012).

Even though dietary fats, have generally received negative publicity, they are essential as part of a balanced diet for overall good health and wellbeing as they give the body energy, cushion organs, give structure to cells and support their growth, assist in the absorption of fat-soluble nutrients (EUFIC, 2015; Yan et al*,* 2024). The fats in fruits and nuts are also used as an energy source and for the many processes in vivo (Cena & Calder, 2020; Zheng et al, 2019). The crude fat content of the *S. mundii* fruits was found to be 0.50 g/100g.

The carbohydrate content of the *S. mundii* fruits was 3.14 g/100g which is comparable with that of many other fruits (Achaglinkame et al*,* 2019 Singh et al, 2023). Dietary carbohydrates serve as the main source of human energy needs, therefore an intake of foods rich in carbohydrates is a necessity for a balanced diet. However, an excessive consumption of low-quality and refined simple carbohydrates has a direct negative impact on health (Clemente-Suarez et al, 2022).

The vitamin C content of the *S. mundii* fruits was 1.21 g/100g. Vitamin C is a vital water-soluble nutrient that cannot be biosynthesised in humans (Qaderi et al, 2023; Gonzalez et al, 2023), therefore, the only source is from food. Fruits and vegetables are the richest natural sources of vitamin C and provide more than 90% of the vitamin requirement in the human diet a well-balanced diet can provide the required amount of vitamin C (Godek et al, 2020).

The ash content of the fruits was 5.51 g/100g, which is an indication of an appreciable content of minerals. The results of the mineral analysis of the fruits of *S. mundii* are shown in Table 2. The mineral analysis revealed that the fruits significant amounts of many of the essential minerals; both macro-minerals and micro-minerals. The concentrations of major minerals on a wet weight basis were as follows: calcium, Ca (4.295 mg/100g), magnesium, Mg (6.042 mg/100g), potassium, K (1.735 mg/100g) and sodium, Na (0.395 mg/100g). The ratio of sodium to potassium was 0.227 mg/100g, which was less than 1.0, the maximum level content of the minerals on wet weight basis were as follows: zinc, Zn (0.753 mg/100g), molybdenum, Mo (0.457 mg/100g), iron, Fe (0.406 mg/100g), manganese, Mn (2.228 mg/100g), nickel, Ni (0.067 mg/100g), copper, Cu (0.034 mg/100g) and cobalt, Co (0.056 mg/100g).

Table 3. Mean content of selected minerals and heavy metals in *S. mundii* fruits (± SD; n=3) and results of similar studies

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Mineral | *S, mundii*,  mg/100g | Vijay & Singh, (2024)  *F. indica,* mg/kg | Nitcheu et al, (2017)  *S. spinosa*  mg/100g | Yimer et al, (2023)  *T. madagascariense*  mg/100g | FAO/WHO  CODEX  Lewis, (2019), mg |
| Ca | 4.295±0.540 | 79.41 - 434.8 | 73.1 | 57.4 – 594.8 | 800 |
| Mg | 6.042± 1.250 | 28.62 - 130.0 | 81.2 | 68.2 – 588.1 | 300 |
| K | 1.735±0.255 | 56.19 - 1184.3 | 1342.4 | 440.6 –1487.8 | - |
| Na | 0.395±0.145 | 139.32-146.3 | 23.3 | 174.9 -277.4 | - |
| P | 0.09± 0.030 | 0.13 – 183.25 | 60.3 | - | 800 |
| Co | 0.056±0.015 | - | - | - | - |
| Cu | 0.034±0.008 | 7.60 – 8.20 | 0.62 | 0.10 -0.50 | 0.3 |
| Cr | 0.088±0.046 | - | - | - | - |
| Fe | 0.406±0.158 | 15.23 – 51.0 | 3.0 | 0.80 – 38.5 | 14 |
| Mn | 2.228±0.095 | 2.85 - 10.9 | - | - | - |
| Mo | 0.457±0.125 | - | - | - | - |
| Ni | 0.067±0.025 | - | - | - | - |
| Zn | 0.753±0.252 | 2.13 – 11.1 | 0.5 | 2.4 – 5.9 | 15 |
| Vitamin C | 1.21±0.43g/100g |  |  |  | 60 |

Zinc plays a critical role in the human body as it is a cofactor of many enzymes (Osredkar & Sustar, 2011). Copper is also an essential micromineral that regulates the functioning of enzymes, stabilising the walls of blood vessels, and connective tissues (Osredkar & Sustar, 2011). Chromium as an essential micromineral is required for sugar and fat metabolism, digestion and absorption of proteins, and fats (Ferit, 2023). There is not enough data to establish Recommended Dietary Allowance (RDA) for chromium, however, an estimated adequate and safe daily dietary intake of 35 μg is recommended (FDA, 2023). The total content of chromium was determined, cognisant of the fact that, chromium (III) is an essential micro-nutrient while chromium (VI) is toxic. The content of heavy metals found in *S. mundii* should, therefore, not be interpreted in isolation, but should be compared to the type of environment in which the tree is growing, and more importantly the concentration of these metals in the soil.

There is little information on the nutrient content of the *Scolopia* species found in the literature. The available research data is about the screening of the antimicrobial and antioxidant properties of extract from the bark and leaves of *Scolopia crenata* (Smitha et al, 2012, Panda et al, 2024). The results were compared the data from two similar studies in South Africa and Ethiopia (Nitcheu et al, 2017, Yimer et al, 2023). The nutrient content was compared with the edible wild fruit in India, the Flacourtiaceae species, *Flacourtia indica* (Indian plum) (Vijay & Singh, 2024) which are from the same subfamily, Salicoideae as the *Scolopia* species. (Lemke, 1988, Stevens, 2015). As shown in Tables 2 and 3, the nutrients and phytochemical content of the fruits of *S. mundii* are comparable fruits of from with those of other edible wild fruits from different parts of the world, South Africa, and in India. In the literature there is scanty information on the phytochemicals content of edible wild fruits. Much of the literature focuses on the antioxidant and antimicrobial activities of the fruit extracts, therefore the quantitative analyses focused on total phenolic content and total flavonoids (Lamien-Meda et al, 2008, Islary, et.al, 2017, Alene et al, 2022).

The results of the quantitative analysis of the phytochemicals are shown in Table 4. The knowledge of the phytochemistry of fruits and vegetables is essential for evaluating their health-promoting properties. The fruits of *S. mundii* had a relatively high amount of saponins, 178.134.52 mg/kg and moderate amounts of total phenolic compounds, 92.365.42 mg/kg. The flavonoid content was very low at 14.50 ± 0.01mg/kg. The fruits contained significant amounts of total phenols, 92.36±5.42 mg/kg.

Table 4. Mean (± SD) Selected phytochemical content of *S. mundii* fruits (n=3)

|  |  |  |  |
| --- | --- | --- | --- |
| Phytochemicals | Content,  mg/kg | Mal et al (2025)  *F. indica,*  µg/mg | Yimer et al, (2023)  *T. madagascariense*  mg/100g |
| Flavonoids | 14.50.10 | 9.56 | - |
| Saponins | 178.13±4.52 | - | - |
| Alkaloids | 17.700.15 | 0.19 | - |
| Total phenolic compounds | 92.365.42 | 34.72 | - |
| Tannins | 58.608.21 | 0.60 | 28.9 |
| Phytates | 5.640.74 | - | 65.5 |
| Oxalate | 138.9015.03 | - | 43.7 |

Foods that are rich in phenolic compounds are potential functional foods due to their various bioactivities, which include antioxidant, anti-inflammatory, antimicrobial, anticancer, immunomodulatory, and vasodilatory properties (Sing & Yadav, 2022). The most common secondary metabolites in foods are said to be polyphenols and have become a subject of interest within the scientific community and research laboratories due to their bioactive properties, bioavailability, and bio-accessibility and their ability to prevent some chronic diseases, such as obesity and type-2 diabetes, which have become prevalent in many populations of the world (Del Rio et al, 2013; Zamora-Ros et al, 2014). The reduced risk of diabetes is linked to flavonoids while some studies have reported that consumption of some particular polyphenols may enable weight loss and avert weight gain due to changes in lipid and energy metabolism (Zamora-Ros et al, 2014; Aloo et al, 2023). The fruits of *S. mundii* may be a potential source of dietary polyphenols and other constituent phytochemicals.

The *S. mundii* fruits contained 178.13±4.52 mg/kg of saponins, which is significantly high relative to the amounts found in some edible wild fruits. (Nyero et al, 2023). Due to their amphiphilic property, saponins exhibit diverse health-promoting biological activities, including antioxidant, antitumor, anti-inflammatory, anti-cancer, lowering of blood cholesterol levels, and are being used for the treatment of obesity, osteoporosis, and sugar diabetes, although their mode of action is not clearly understood (Oleszek & Oleszek, 2021; Timilsena et al, 2023; Zhong et al, 2022). However, a high dietary intake of saponins has been reported to inhibit the absorption of minerals such as iron, zinc, and calcium by forming insoluble saponin-mineral complexes. ([Samtiya et al., 2020](https://www.sciencedirect.com/science/article/pii/S2772753X23000114" \l "bib0068)).The content of tannins was found to be 58.608.21 mg/kg in *S. mundii* fruits. Tannins have a long rich history of use in traditional herbal medicine due to antioxidant properties (Sharma et al. 2019). Tannins have also been shown to exhibit antimutagenic activity and antimicrobial activity. The antimutagenic activity of tannins may be attributed to their antioxidative properties while the presence of tannins in fruits thus serves as a natural defence mechanism against microbial infections in fruits (Chung et al, 1998). Tannins exhibit anti-hypertensive and vasodilatory effects, implying that consuming foods rich in tannins could improve the cardiovascular system’s health (Turgut et al, 2015).

The alkaloid content of the *S. mundii* fruits was very low at 17.700.15 mg/kg. Alkaloids are important compounds in human life as they exhibit a wide variety of medicinal properties, however their practical clinical use is limited because of their addictive properties. There is no general health-based guidance limit for pyrrolizidine alkaloids. However, researchers at the European Food Safety Authority (EFSA) have established a reference value of 237 μg/kg body weight per dayto assess the carcinogenic risks posed by pyrrolizidine alkaloids (EFSA, 2017). This value was considered low enough for public health safety (FAO/WHO, 2015) and is generally considered protective enough for humans. Plant alkaloids have been used by man for centuries as for example, remedies, human organs stimulants, potions. Presently some plant alkaloids are used as anticancer agents, cardioprotective agents, antidiabetic agents, immune stimulants, anti-inflammatory agents, and as antivirals (Watson et al, 2001). There are a few reports on alkaloids in fruits, because most researchers focus on alkaloids and other secondary metabolites in medicinal plant species but not in foodstuffs (Arbo et al, 2008). Therefore, since this study indicated significant content of alkaloids in *S. mundii* fruits, it will be worthwhile to do a more comprehensive study of the nutritional value of the fruits.

The high content of oxalates, 138.9015.03 mg/kg in the *S. mundii* fruits may have some adverse effects as oxalates bind calcium and to a lesser extent, other minerals in the stomach and thus reduce their absorption. High dietary oxalate intake has traditionally been linked with the formation of kidney stones in humans ([Crivelli et al, 2021](https://www.sciencedirect.com/science/article/pii/S1756464622000081" \l "b0100)). However, the dietary approaches to stop hypertension (DASH diet) with a high consumption of vegetables generally high in oxalates, have been reported to reduce the risk of kidney stone formation (Mitchel et al, 2019). The *S. mundii* fruits were found to contain a low amount of phytates, 5.64±0.74 mg/kg in this study. Dietary phytates have long been reported as anti-nutrients that reduce the absorption of minerals, such as calcium, iron, and zinc from the diet (Petroski & Minich, 2020), but they are also known to exhibit antioxidant and antidiabetic properties with the ability to lower blood glucose levels (Sanchis et al, 2018). The disproportionate consumption of phytates may also lower utilisation of dietary protein (Bora, 2014). On the other hand, some studies have suggested that an intake of phytate-rich foods may be beneficial as phytates exhibit antioxidant property (Goufo & Trindade, 2014) and inhibit the formation of calcium oxalate kidney stones (Grases et al, 2000). The phytates content of the fruits is low to be of any health concern. The fruit juice of *S. mundii* was compared with some major brands of fruit juices on the market. Considering its very good nutritional profile, especially of vitamin C, fibre and microminerals, the *S. mundii* puree has a great potential as a product in the beverages segment.

4. Conclusion

This study shows that the fruits of *S. mundii* contain significant amounts of essential nutrients such as protein, carbohydrates, lipids, both macrominerals and microminerals, vitamin C, and phytochemicals. Wild edible fruits and vegetables have often been regarded as poverty foods within the Southern African sub-region. However, the results of this study have shown the potential of the fruits from *S. mundii,* a wild tree, to provide humans with most of the necessary nutrients. Fruits of *S. mundii* are nutritious, and may serve as a cheaper source of nutritious food, and with health benefits. The results suggest that consuming *S. mundii* fruits may address rural household dietary diversity and food insecurity, and that the fruits could be used as a food security coping strategy at household level and among shepherd boys who are the major consumers. Furthermore, the results may be used to dispel the negative perceptions towards the consumption of wild edible fruits. Thus, the need to include wild edible fruits such as those of *S. mundii* in efforts to alleviate food insecurity and micronutrient malnutrition among rural communities cannot be ignored. Knowledge and awareness of the health benefits of the *S mundii* fruits could positively influence choices and preferences towards the consumption of these wild edible fruits and dispel the negative perception towards consumption of wild fruits and vegetables by the urban population. A series of more detailed analyses of fresh *S. mundii* fruits should be explored and the potential for making and packing the juice explored.

**DISCLAIMER (ARTIFICIAL INTELLIGENCE)**

Authors hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, etc.,) was used in preparing then manuscript.

References

Achaglinkame, M. A., Aderibigbe, R.O., Hensel, O., Sturm, B., & Korese, J.K. (2019). Nutritional Characteristics of Four Under-utilized Edible Wild Fruits of Dietary Interest in Ghana. Foods, 8, 104; doi:10.3390/foods8030104

Agostinho, A.J., de Souza O., Woodland, A., Santos. D.S., Caldas, J.C. (2016)*.* Simple and Sensitive Spectrophotometric Method for Phytic Acid Determination in Grains. Food Anal. Methods, 9, 2087–2096.<https://doi.org/10.1007/s12161-015-0387-0>

Akter, R., Chowdhury, M.A., & Rahman, M.H. (2021). Flavonoids and polyphenolic compounds as potential talented agents for the treatment of Alzheimer’s disease and their antioxidant activities. Curr Pharm Des., 27:345–56. 10.2174/1381612826666201102102810

Alene, A.N., Teshager, A.A., Kassie, D.A., Abate, G.Y., Mengstie, M.A., Mekonnen, S.D., et al (2022). Nutraceutical, phytochemical, and antioxidant activities of selected wild edible fruits as natural foods. Poly Journal of Engineering and Technology, 1(1), 46-63.

Aloo, S.-O., Ofosu, F.K., Kim, N.-H., Kilonzi, S.M., & Oho, D-H. (2023). Insights on Dietary Polyphenols as Agents against Metabolic Disorders: Obesity as a Target Disease. Antioxidants, 12(2), 416 <https://doi.org/10.3390/antiox12020416>

AOAC (2016). AOAC Method 967.21. Official Methods of Analysis 22nd ed. Arlington, VA, Association of Official Analytical Chemist. 806-842.

Arbo M., Larentis E., Linck V., Aboy A., Pimentel A., Henriques A., et al. (2008). Concentrations of p-synephrine in fruits and leaves of Citrus species (Rutaceae) and the acute toxicity testing of Citrus aurantium extract and p-synephrine. Food Chem. Toxicol,46:2770–2775. doi:10.1016/j.fct.2008.04.037.

Berry, E.M., Dernini, S., Burlingame, B., Meybeck, A. & Conforti, P. (2015). Food Security and Sustainability: Can One Exist Without the Other? Public Health Nutr. 18, 9.

Biluca F.C., da Silva B., Caon T., Mohr E.T.B., Vieira G.N., Gonzaga L.V., et al. (2020). Investigation of phenolic compounds, antioxidant and anti-inflammatory activities in stingless bee honey (Meliponinae). Food Res Int., 129: 108756. doi: 10.1016/j.foodres.2019.108756.

Bora, P. (2014). Anti-nutritional factors in foods and their effects. Journal of Academia and Industrial Research, 3(6): 285–290.

Bvenura C., & Sivakumar D. (2017). The role of wild fruits and vegetables in delivering a balanced and healthy diet. Food Res Int. 99(Pt 1):15-30. doi: 10.1016/j.foodres.2017.06.046

Cavender A. (2006). Folk medical uses of plant foods in southern Appalachia, United States. *Journal of Ethnopharmacology*, 108(1):74–84. doi: 10.1016/j.jep.2006.04.008. PMID: 16806760

Cena H., & Calder P.C. (2020). Defining a healthy diet: evidence for the role of contemporary dietary patterns in health and disease. Nutrients,12:334. doi:10.3390/nu12020334

Chang, C. C., Yang, M. H., Wein, H. M., & Chern, J. C. (2002). Estimation of total flavonoid content in propolis by two complementary colorimetric methods. J. of Food and Drug Analysis, 10(3), 178–182.<https://doi.org/10.38212/2224-6614.2748>

Chung, K.T., Wong, T.Y., Wei. C.I, Huang, Y.W., & Lin, Y. (1998). Tannins and human health: a review. Crit Rev Food Sci Nutr.,38(6):421-64. doi: 10.1080/10408699891274273. PMID: 9759559

Crivelli, J.J., Mitchell, T., Knight, J. Wood, K.D., Assimos, D.G., Holmes, R.P., et al. (2021). Contribution of Dietary Oxalate and Oxalate Precursors to Urinary Oxalate Excretion, Nutrients, 13, p. 62.

Del Rio, D., Rodriguez-Mateos, A., Spencer, J.P., Tognolini, M., Borg, G., Crozier, A. (2013). Dietary (poly)phenolics in human health: structures, bioavailability, and evidence of protective effects against chronic diseases. Antioxid Redox Signal., 10;18(14):1818-92. doi:10.1089/ars.2012.4581. PMID: 22794138, PMCID: [PMC3619154](https://pmc.ncbi.nlm.nih.gov/articles/PMC3619154/)

Dreher M.L. (2018). Whole Fruits and Fruit Fiber Emerging Health Effects*.* Nutrients. 28;10(12):1833. doi: 10.3390/nu10121833

EFSA (2017). Panel on Contaminants in the Food Chain (CONTAM). Risks for human health related to the presence of pyrrolizidine alkaloids in honey, tea, herbal infusions and food supplements. EFSA Journal*,* 15(7):4908-XX. doi: 10.2903/j.efsa.2017.4908

Ejikeme, C.M., Ezeonu, C. S., & Eboatu, A.N. (2014). Determination of physical and phytochemical constituents of some tropical timbers indigenous to Niger Delta Area of Nigeria. European Scientific Journal,10(18): 247–270.

EUFIC (2015). European Food Information Council The Functions of Fats in the Body Available online at: <https://www.eufic.org/en/whats-in-food/article/facts-on-fats-dietary-fats-and-health>. [Accessed 16 June 2025]

FAO, (2003). Food energy - methods of analysis and conversion factors. Food and Nutrition Paper 77, Report of a Technical Workshop, Rome, 3-6 December 2002. Food and Agriculture Organization of the United Nations, Rome.

FAO (2016). Indigenous Peoples’ food systems & well-being: Interventions and policies for healthy communities. Food and Agriculture Organization of the United Nations.  
<https://www.fao.org/3/i3144e/i3144e.pdf>

Daily Value and Percent Daily Value on the Nutrition and Supplement Facts Labels, 2023

https://www.fda.gov/food/nutrition-facts-label/daily-value-nutrition-and-supplement-facts-labels. Retrieved 24 June 2025.

**Ferit K. (2023).** Chromium and glucose metabolism: The essential trace mineral's impact on blood sugar control. Perspective Diabetes Manag, 13(6), 542–543.

Fruhbeck, G., Alonso, R., Marzo, F., & Santidrian, S. (1995). A Modified Method for the Indirect Quantitative Analysis of Phytate in Foodstuffs. Analytical Biochemistry, 225(2), 206-212. https://doi.org/10.1006/abio.1995.1145.

Gaston, R.T., Habyarimana, F., & Ramroop, S. (2022). Joint modelling of anaemia and stunting in children less than five years of age in Lesotho: a cross-sectional case study. BMC Public Health, 22(1), 285. doi: 10.1186/s12889-022-12690-3. PMID: 35148690; PMCID: PMC8840695.

Germishuizen, G., Meyer, N.L., Steenkamp, Y. & Keith, M. (eds) (2006). A Checklist of South African plants. Southern African Botanical Diversity Network Report No. 41. SABONET, Pretoria.

González-Zamorano, L., Cámara, R. M., Morales, P., & Cámara, M. (2025). Harnessing Edible Wild Fruits: Sustainability and Health Aspects. *Nutrients*, *17*(3), 412. https://doi.org/10.3390/nu17030412

Ghorai, N., Ghorai, S., Chakraborty, S., Gucchait, S. K., & Saha~~,~~ & S. Biswas, (2012). Estimation of total terpenoids concentration in plant tissues using a monoterpene, Linalool as standard reagent. Protocol Exchange, 5(10),1038.

Godek, M., Knysz, P., Lechowski J., Ziomek M., Drozd Ł., Szkucik, K. (2020). Vitamin C content in edible tissues of snails harvested in Poland. Med. Weter, 76 (10), 580-584.

Gonzalez, M.J.; Miranda-Massari, J.R., & Olalde, J. (2023). Chapter 9 —Vitamin C and mitochondrial function in health and exercise. In Molecular Nutrition and Mitochondria; Ostojic, S.M., Ed.; Academic Press: Cambridge, MA, USA, pp. 225–242.

Goufo, P., & Trindade, H. (2014). Rice antioxidants: phenolic acids, flavonoids, anthocyanins, proanthocyanidins, tocopherols, tocotrienols, γ-oryzanol, and phytic acid. Food Sci Nutr. 2, 75–104. doi: 10.1002/fsn3.86

Grases, F., March, J.G., Prieto, R.M., Simonet, B.M., Costa-Bauzá, A., García-Raja, A., et al. (2000). Urinary phytate in calcium oxalate stone formers and healthy people: dietary effects on phytate excretion. Scand J Urol Nephrol., 34,162–4. doi:10.1080/003655900750016526

Gumoshabe, M., Anywar, G., & Tugume, P. (2023). Access to provisioning services by local communities from Mpanga central forest reserve in central Uganda. Front. For. Glob. Change,6,1021664. doi:10.3389/ffgc.2023.1021664

Harborne, A. J. (1998). Phytochemical methods a guide to modern techniques of plant analysis. Springer Science & Business Media. <https://doi.org/10.1016/B978-0-12-818593-3.00001-4>

Islary, A., Sarmah, J., & Basumatary, S. (2017). Nutritional value, phytochemicals and antioxidant properties of two wild edible fruits (*Eugenia operculata* Roxb. and *Antidesma bunius* L.) from Assam, North-East India. Mediterranean Journal of Nutrition and Metabolism, 10(1), 29-40. doi:[10.3233/MNM-16119](https://doi.org/10.3233/MNM-16119)

Jaeger, R., & Cuny, E. (2016). Terpenoids with Special Pharmacological Significance: A Review. Nat Prod Commun. 11(9),1373-1390. PMID: 30807045

Kgosana, K.G. (2019). The effects of extraction techniques and quantitative determination of oxalates in Nerium oleander and feeds. Onderstepoort J. Vet. Res. 86(1),1-9.

Klinde, A., Shen, Q., Heppel, S., Lovegrove, J.A., Rowland I., & Tuohy K.M. (2016). Impact of increasing fruit and vegetables and flavonoid intake on the human gut microbiota. Food Funct.,7,1788–1796. doi: 10.1039/C5FO01096A.

Lamien-Meda, A., Lamien, C. E., Compaoré, M. M. Y., Meda, R. N. T., Kiendrebeogo, M., Zeba, B., et al (2008). Polyphenol Content and Antioxidant Activity of Fourteen Wild Edible Fruits from Burkina Faso. Molecules, 13(3), 581-594. <https://doi.org/10.3390/molecules13030581>

Lemke, D. (1988). A synopsis of Flacourtiaceae, Aliso 12(1), 29-43. [doi](https://en.wikipedia.org/wiki/Doi_(identifier)):[10.5642/aliso.19881201.05](https://doi.org/10.5642%2Faliso.19881201.05). Retrieved 23 June 2025

Lewis, J. 2019. Codex nutrient reference values. Rome. FAO and WHO.

Lyamuya, R. D., Mwakalebe, G.G., Munisi, E., Masenga, E., & Hariohay, K.M. (2023). Traditional knowledge on wild edible vegetables consumed by communities around Serengeti ecosystem, northern Tanzania. International Journal of Biodiversity and Conservation, 15(2), 70-78. DOI: 10.5897/IJBC2022.1573

Ma, W., Nguyen, L.H., Song, M., Jovani, M., Liu, P.H., Cao, Y., & et al. (2019). Intake of dietary fiber, fruits, and vegetables, and risk of diverticulitis. The American Journal of Gastroenterology. 114(9):1531-1538. doi: 10.14309/ajg.0000000000000363

Mal, B., Mondal,S., Kuila, D., Mridha, M., & Biswas G. (2025). Food value analysis, phytochemical profiling, LC/MS analysis, antioxidant and antimicrobial activity of methanolic extract of *Flacourtia indica* (Burm.f.) Merr. Fruits of lateritic West Bengal. Prospects in Pharmaceutical Sciences, 23(2), 84-95. <https://doi.org/10.56782/pps.311>

Mbenyane, X.G. (2017). Indigenous foods and their contribution to nutrient requirements. South AfricanJournal of Clinical Nutrition, 30(4),5-7.

Merrill, A.L., & Watt, B.K. (1973). Energy Value of Foods: Basis and Derivation. Agriculture Handbook No. 74, ARS United States Department of Agriculture, Washington DC.

Miller, V., Mente, A., Dehghan S., Rangarajan, S., Zhang, X., Swaminathan, S., et al. (2017). Fruit, vegetable, and legume intake, and cardiovascular disease and deaths in 18 countries (PURE): A prospective cohort study. *Lancet.*390:2037–2049. doi:10.1016/S0140-6736(17)32253-5.

Moo-Huchin, V.M., Moo-Huchin M.I., Estrada-León, R.J., Cuevas-Gloryc, L., Estrada-Motaa I.A., Ortiz-Vázquezc, E., et al. (2015). Antioxidant compounds, antioxidant activity and phenolic content in peel from three tropical fruits from Yucatan, Mexico. Food Chem*.* 166,17–22. doi: 10.1016/j.foodchem.2014.05.127.

Moteetee, A., Moffett, R.O., & Seleteng-Kose, L. (2019). A review of the ethnobotany of the Basotho of Lesotho and the Free State Province of South Africa (South Sotho). [South African Journal of Botany](https://www.sciencedirect.com/journal/south-african-journal-of-botany), [122](https://www.sciencedirect.com/journal/south-african-journal-of-botany/vol/122/suppl/C), 21-56.

Nemzer, B.V., Kalita, D., Yashin, A.Y., & Yashin, Y.I. (2020). Bioactive compounds, antioxidant activities, and health beneficial effects of selected commercial berry fruits: a review. *J Food Res*., 9,78–101. doi: 10.5539/jfr.v

Ngemakwe, P.H.N., Remize, F., Thaoge, M.L. & Sivakumar, D. (2017). Phytochemical and nutritional properties of underutilised fruits in the southern African region. South African Journal of Botany, 113, 137-149. Doi: <https://doi.org/10.1016/j.sajb.2017.08.006>.

Ntlanga, S.S., Jiba, P., Christian, M., & Mdoda, L. (2023). Assessing Awareness and Perceptions Towards the Existence of Indigenous Foods in Port St Johns of the Eastern Cape South Africa. S. Afr. J. Agric. Ext. 51(3), 115-134. doi: 10.17159/2413-3221/2023/v51n3a13952

Nxusani, Z. N., Zuma, M. K., & Mbhenyane, X. G. (2023). A Systematic Review of Indigenous Food Plant Usage in Southern Africa. Sustainability, *15*(11), 8799. https://doi.org/10.3390/su15118799

Nyero, A., Anywar, G.U., Achaye, I., & Malinga, G.M. (2023). Phytochemical composition and antioxidant activities of some wild edible plants locally consumed by rural communities in northern Uganda. Frontiers in Nutrition, Front. Nutr. 10,1070031. doi: 10.3389/fnut.2023.1070031

Obadoni B.O., & Ochuko, P.O. (2001). Phytochemical studies and comparative efficacy of the crude extracts of some homeostatic plants in Edo and Delta States of Nigeria. Global J. Pure Appl. Sci. 8(2), 203-208.

Oleszek, M., & Oleszek, W. (2021). Saponins in Food. In: Xiao, J., Sarker, S.D., Asakawa, Y. (eds) Handbook of Dietary Phytochemicals. Springer, Singapore. https://doi.org/10.1007/978-981-15-4148-3\_34

Omotayo, A.O., & Aremu, A.O. (2020). Underutilized African indigenous fruit trees and food–nutrition security: Opportunities, challenges, and prospects. *Food and Energy Security,* 9(3), 1-16. <https://doi.org/10.1002/fes3.220>

[Osredkar J., & Sustar N. (2011) Copper and zinc, biological role and significance of copper/zinc imbalance. Journal of Clinical Toxicology, 3, 1-18.](https://www.longdom.org/open-access/copper-and-zinc-biological-role-and-significance-of-copper-zincimbalance-2161-0495.S3-001.pdf)

Panda, S.S., Mohanta, O., Kumar Das ,P., Sahoo, A., Jena, S., Asit Ray, et al, (2024). *Scolopia crenata* leaf essential oil as a rich and novel source of benzaldehyde. Chemistry of Natural Compounds, 60(6), 1168-1171 DOI 10.1007/s10600-024-04549-3

Pawlos, Z., Chandravanshi, B.S., Yohannes, W., & Embiale, A (2021). Levels of selected metals in *Ficus sur* Forssk fruit and soil of the plant grown in different parts of Ethiopia*.* SINET: Ethiop. J. Sci. 44, 1–12.

Pullaiah, T., K. Krishnamurthy, and B. Bahadur. 2017. Ethnobotany of India, Volume 3: North-East India and the Andaman and Nicobar Islands. Apple Academic Press.

Qaderi, R., Mezzetti, B., Capocasa, F. & Mazzoni, L. (2023). Stability of Strawberry Fruit (*Fragaria xananassa* Duch.) Nutritional Quality at Different Storage Conditions. Appl. Sci., 13, 313.

Roux, J. P., (2003). Delonix regia. Flora of South Africa. Global Plants.

Samtiya, M., Aluko, R.E., & Dhew, T. (2020). Plant food anti-nutritional factors and their reduction strategies: An overview. Food Production, Processing and Nutrition,2(1), 1-14.

Sanchis P.R., Rivera F., Berga R., Fortuny M., Adrover A., Costa-Bauza F., et al. (2018). Phytate decreases formation of advanced glycation end-products in patients with Type II diabetes: randomized crossover trial. Scientific Reports 8, 9618. doi: 10.1038/s41598-018-27853-9

Santhi, K., & Sengottuvel, R., (2016). Qualitative and Quantitative Phytochemical analysis of *Moringa concanensis* Nimmo. International Journal of Current Microbiology and Applied Sciences 5(1), 633-640. doi:[10.20546/ijcmas.2016.501.064](http://dx.doi.org/10.20546/ijcmas.2016.501.064)

Sarfo, J., Pawelzik, E., & Keding, G.B. (2023). Fruit and vegetable processing and consumption: Knowledge, attitude, and practices among rural women in East Africa. Food Sec*.* 15, 711–729. <https://doi.org/10.1007/s12571-022-01343-3>

Shaheen, S., Ahmad, M., & Haroon, N. (2017). Edible wild plants: An alternative approach to food security. Springer International Publishing AG. doi: https://doi.org/10.1007/978-3-319-63037-3

Sharma K., Kumar V., Kaur J., Tanwar B., Goyal, A., Sharma R., et al (2019). A. Health effects, sources, utilization and safety of tannins: A critical review. Toxin Rev., 1–13.

doi: 10.1080/15569543.2019.1662813

Sibiya N.P. (2012). Nutritional value of selected wild edible indigenous fruits of Southern Africa and their commercial potential. (Master’s Dissertation). Johannesburg: University of Johannesburg. Available from: http://hdl.handle.net/102000/0002 [Accessed: 17 June 2025].

Nitcheu Ngemakwe, P.H., Remize, F., Thaoge, M.L. & Sivakumar, D. (2017). Phytochemical and nutritional properties of underutilised fruits in the southern African region. South African Journal of Botany, 113, 137-149. https://doi.org/10.1016/j.sajb.2017.08.006.

Singh, J., Rajasekaran, A., Negi, A.K., Pala, N.A., Vijender, P. Panwar, R.W, et al. (2023). Potential of wild edible fruits for nutrition in indigenous communities of Northwest Himalaya, India. Ethnobotany Researchand Applications, 25(9), 1-15. doi:10.32859/era.25.9.1-15

Skrypnik, L. Novikova, A. & Tokupova, E. (2019). Improvement of Phenolic Compounds, Essential Oil Content and Antioxidant Properties of Sweet Basil (*Ocimum basilicum* L.) Depending on Type and Concentration of Selenium Application. Plants*,* 8(11)*,* 458. https://doi.org/10.3390/plants8110458

Smitha P. Venkata, Murali, M.C., Teixeira da Silva, J.A., Raju, B.A., & Sravani, R. (2012). Screening the Antimicrobial and Antioxidant Potential of *Ventilago denticulata*, *Scolopia crenata* and *Rivea hypocrateriformis* from Maredumilli Forest, India. Medicinal and Aromatic Plant Science and Biotechnology, 6 (1), 58-62.

Soliman, G.A. (2019). Dietary fiber, atherosclerosis, and cardiovascular disease. Nutrients*.* 2019; (5),1155. DOI: dor.org/10.3390/nu11051155

Sorescu, A.A., Nuta. A., & Ion, R, M. (2017). Qualitative screening of phytochemicals found in aqueous extracts of Prunus domestica stone. In: Proceedings of the International Conference. “Agriculture and Food for the XXI Century” (AGRIFOOD ‘17), 11-13 May 2017; Sibiu, Romania. pp. 121-126

Stadlmayr, B, Trübswasser, U, McMullin, S, Karanja, A, Wurzinger, M, Hundscheid, L, et al. (2023). Factors affecting fruit and vegetable consumption and purchase behaviour of adults in sub-Saharan Africa: A rapid review', Frontiers in Nutrition*,* 10, 1113013. https://doi.org/10.3389/fnut.2023.1113013

Stevens, P.F. (2015) [1st. Pub. 2001]. Angiosperm Phylogeny Website, Retrieved 23 June 2025

Sun Trees (2018). *Scolopia mundii* – Rooipeer – Red pear. Available online at: <https://suntrees.co.za/scolopia-mundii-rooipeer-red-pear/> [Accessed: June 16 2025]

Srivastavaa, A., Pantb, P., Maheshwaric, B., & Siddiquia, S. (2024). Phytochemicals in functional foods: fortifying nutritional value and health benefits. Reviews In Food And Agriculture (RFNA), 5(2),112-121. doi: http://doi.org/10.26480/rfna.02.2024.112.121

Teklehaimanot T. (2008), “The role of indigenous fruit trees in sustainable dryland agriculture in Eastern Africa,” Indigenous Fruit Trees in the Tropics: Domestication, Utilization and Commercialization, CABI, Wallingford, UK, 204–223.

Thakur M., Singh, K., & Khedkar, R. (2020). Phytochemicals: Extraction process, safety assessment, toxicological evaluations, and regulatory issues, In Bhanu Prakash, (Ed.) [Functional and Preservative Properties of Phytochemicals](https://www.sciencedirect.com/science/book/9780128185933), Academic Press, 341-361 <https://doi.org/10.1016/B978-0-12-818593-3.00011-7>

Timilsena YP, Phosanam A, Stockmann R. (2023). Perspectives on Saponins: Food Functionality and Applications. Int J Mol Sci. 24(17),13538. doi: 0.3390/ijms241713538.

Ullah A, Munir S, Badshah SL, Khan N, Ghani L, Poulson BG, Emwas AH, Jaremko M. (2020). Important Flavonoids and Their Role as a Therapeutic Agent. Molecules, 25(22),5243. doi: 10.3390/molecules25225243. PMID: 33187049; PMCID: PMC7697716.

Van Wyk, B. E. (2017). A Review of African Medicinal and Aromatic Plants. Medicinal and Aromatic Plants of the World-Africa, 3, 19–60.

Veronese N., Solmi, M., Caruso, M.G., Giannelli, M.G., Osella, A.R., Evangelou, E. et al. (2018). Dietary fiber and health outcomes: An umbrella review of systematic reviews and meta-analyses. Am. J. Clin. Nutr.,107, 436–444. DOI: 10.1093/ajcn/nqx082

Watson, A., Fleet, G., Asano, N., Molyneux, R., & Nash, R. (2001). Polyhydroxylated alkaloids - Natural occurrence and therapeutic applications. Phytochemistry.2001; 56:265-295. DOI: 10.1016/S0031-9422(00)00451-9.

Vijay, M.K., Singh, N. (2024). Nutritional Composition, phytochemistry, and pharmacognostic activities of *Flacourtia indica* (Burm.f.) Merr. An important wild edible fruit species of central India. International Journal of Advanced Biochemistry Research, 8(7), 765-771. DOI: https://doi.org/10.33545/21674693.2024.v8.i7j.158

WHO (2020). World Health Rankings / WHO Data. Malnutrition in Lesotho: Deaths*.* Retrieved from https://www.worldlifeexpectancy.com/lesotho-malnutrition [Accessed 15 May 2025]

Wolfe, R. R. (2012). The role of dietary protein in optimizing muscle mass, function and health outcomes in older individuals. British Journal of Nutrition, 108(S2), S88–S93. doi:10.1017/S0007114512002590

Yan, X., Huang J., Huang, L., Luo, C., Li, Z., Xu, P., et al. (2024). Effects of dietary lipids on bioaccessibility and bioavailability of natural carotenoids. LWT, 200, 116171. <https://doi.org/10.1016/j.lwt.2024.116171>.

Yimer, A., Forsido, S.F., Getachew A., & Abebe, A. (2023). Nutritional composition of some wild edible plants consumed in Southwest Ethiopia. Heliyon, 9(6), e16541

Zamora-Ros R, Forouhi, N.G., Sharp, S.J., González, C.A., Buijsse, B., Guevara, M., et al (2014). Dietary intakes of individual flavanols and flavonols are inversely associated with incident type 2 diabetes in European populations. J. Nutr. 144(3),335-43. DOI: 10.3945/jn.113.184945

Zhao, L., Yuan, X., Wang, J., Feng, Y., Ji, F., Li, Z., & Bian, J. (2019). A review on flavones targeting serine/threonine protein kinases for potential anticancer drugs. Bioorganic Med. Chem., 27: 677 - 685. doi: 10.1016/j.bmc.2019.01.027.

Zheng, L., M., Fleith, F., Giuffrida, B.V., O'Neill, N., & Schneider., N. (2019). Dietary polar lipids and cognitive development: a narrative review. Adv. Nutr., 1;10(6),1163-1176.

Zhong, J., Tan, L., Chen, M., & He, C. (2022). Pharmacological activities and molecular mechanisms of Pulsatilla saponins. Chin. Med., 17:59. doi: 10.1186/s13020-022-00613-8.