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Ethnobotanical, biological, and phytochemical qualities of locally sourced leafy vegetables for food security, good health and general well-being in South Africa: A review

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ABSTRACT

Despite the cultural and nutritional importance associated with locally sourced leafy vegetables, they are largely overlooked and underutilized globally. In this review, we provide an appraisal of the ethnobotanical uses, biological and chemical profiles of locally available leafy vegetables in South Africa. A comprehensive search was conducted using various scientific databases and ethnobotanical books, with a timeline from January 2010 to August 2023. This yielded 11 eligible scientific articles that generated an inventory of 67 locally sourced leafy vegetables from 23 plant families. The most mentioned leafy vegetables were *Bidens pilosa* (8), *Vigna unguiculata* (6), *Amaranthus hybridus* (6), *Chenopodium album* (5), and *Cleome gynandra* (5). In terms of plant families, Amaranthaceae (17.9 %), Asteraceae (10.4 %), Cucurbitaceae (11.9 %), Malvaceae (7.4 %), and Urticaceae (5.9 %) were the most represented groups. Based on the ethnobotanical data, these leafy vegetables possess several medicinal uses, with indications for different health conditions affecting humans and livestock. We highlighted the wide range of health benefits of these leafy vegetables, which are linked to their diverse nutrients (e.g., vitamins, minerals, and dietary fiber) and phytochemicals. The recorded leafy vegetables are known to exert diverse biological activities and health benefits. Furthermore, the phytochemical profiles revealed the presence of various bioactive compounds, such as polyphenols, alkaloids, saponins, and flavonoids, in these locally sourced leafy vegetables. Taken together, the evidence from the existing ethnobotanical surveys, biological activities, and phytochemical profiles revealed the importance of these locally available leafy vegetables for food security, good health, and general well-being in South Africa.

1. Introduction

In recent years, there has been an increasing recognition of the importance of underutilized leafy vegetables in promoting food and nutrition security, as well as sustainable agriculture (Akinola et al., 2020; Maseko et al., 2018). South Africa boasts a rich diversity of leafy vegetables, many of which have been used for centuries among local communities (Njume et al., 2014; Omotayo et al., 2020). These leafy vegetables possess unique characteristics that make them well-suited to local environmental conditions, requiring minimal water and fertilizer inputs (Maseko et al., 2018; Omotayo et al., 2020). Moreover, they are rich in essential nutrients, vitamins, and minerals, which are crucial for maintaining good health and general well-being (Njume et al., 2014). Ethnobotanical studies play a crucial role in understanding the relationship between plants and people within specific ecosystems (van Wyk, 2002; Weckerle et al., 2018). Understanding the ethnobotanical uses of leafy vegetables is crucial for promoting sustainable practices, preserving traditional knowledge, and enhancing food security (Bvenura and Afolayan, 2014).

Leafy vegetables are known for their nutritional value, medicinal properties, and cultural significance thereby playing vital roles in traditional diets and cultural practices of various communities in South Africa. However, the traditional knowledge and practices related to leafy vegetables are often at risk of being lost due to the rapid urbanization and modernization. Furthermore, locally available leafy

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vegetables are often neglected and underutilized leading to a decline in their availability, thereby posing a threat to food security and biodiversity (Imathiu, 2021; Maseko et al., 2018). The erosion of indigenous knowledge regarding leafy vegetables due to their perceived low value remain a concern. Despite their nutritional value, underutilized leafy vegetables have been historically neglected due to associations with poverty and rural households (Shackleton et al., 2010). By re-assessing the indigenous knowledge and practices associated with these leafy vegetables, we can gain valuable insights into their potential benefits and significance in local communities. Researchers have recognized the nutritional value and medicinal properties of leafy vegetables in South Africa (Akinola et al., 2020; Mungofa et al., 2022; Njume et al., 2014; Shayanowako et al., 2021). For instance, some indigenous leafy vegetables have potential in the prevention of age-related degenerative diseases, such as stroke and arteriosclerosis (Kwinana-Mandindi, 2014). Therefore, understanding the indigenous knowledge and practices associated with these leafy vegetables can guide efforts toward their reintroduction as part of the local food systems, contributing to improved food and nutrition security, good health, well-being, and sustainable livelihoods. In this review, we aim to provide a critical appraisal on some locally sourced leafy vegetables in South Africa from ethnobotanical, biological and phytochemical perspectives. This is envisaged to generate evidence-based data for future research and provide timely recommendations for pertinent interventions in the food system of South Africa.

2. Material and methods

To identify information on the ethnobotanical uses of locally sourced leafy vegetables in South Africa, a web-based systematic literature search was conducted to obtain literature published from January 2010 to August 2023. The systematic review was conducted according to PRISMA guidelines for reporting systematic reviews and meta-analyses (Moher et al., 2009). Electronic databases such as Google Scholar (n=140), ScienceDirect (n=69) and Scopus (n=37) were used to search for literature, including journal articles, books, theses, and dissertations. These databases were searched using keywords/phrases such as leafy vegetables, ethnobotany, and ethnobotanical uses coupled with South Africa. The scientific names of the leafy vegetables were verified using the 'World Flora Online' (WFO, 2024 https://www.worldfloraonline.org/, 30th May 2024). The process of screening search results included reviewing the titles and abstracts of articles to determine their relevance and eligibility for inclusion. Selected research articles were downloaded for further assessment. The critical assessment of these articles involved evaluating how they met the predetermined inclusion criteria. The ethnobotanical articles not focusing on South Africa and leafy vegetables were also excluded. Review and non-English articles were excluded from this study. To generate data on the biological effects and phytochemical profiles, each of the recorded plants was individually searched online.

3. Results and discussion

3.1. Literature search output

A total of 246 studies were recorded from various scientific databases (Fig. 1), which included journal articles, theses, books, and dissertations from January 2010 to August 2023. After screening, 235 studies were excluded based on the inclusion and exclusion criteria, while 11 studies were eligible (Fig. 1). In this review, the eligible studies covered five out of the nine provinces in South Africa. The provinces included Limpopo, KwaZulu-Natal, Eastern Cape, North-West and Mpumalanga (Table 1). Eastern Cape Province was the most active research-based in locally sourced leafy vegetables, probably due to its being characterized by subtropical climates, cold and wet winters, as well as warm and wet summers (Magaya, 2021).

Understanding the different uses of locally sourced leafy vegetables is important as it projects the existing knowledge between leafy vegetables and humans (Shayanowako et al., 2021). They form a valuable reference for future research to generate empirical data on utilization and benefits. However, studies documenting the numerous uses of leafy vegetables remain limited in South Africa. Existing details on the various uses of leafy vegetables are often acquired from household farmers and indigenous knowledge holders in rural communities (Table 1).

3.2. Botanical overview of the documented leafy vegetables

3.2.1. Recorded leafy vegetables and their distribution across plant families

The eligible studies generated an inventory of 67 locally available leafy vegetables in South Africa (Table 2). *Bidens pilosa* (8), *Vigna unguiculata* (6), *Amaranthus hybridus* (6), *Cleome gynandra* (5), *Amaranthus spinosus* (3), *Centella coriacea* (3), *Chenopodium album* (5), *Ipomoea batatas* (3), *Solanum retroflexum* (3), and *Sonchus asper* (3) were the most frequently mentioned plant species. In Kenya, *Bidens pilosa* is used as a traditional leafy vegetable for improving human health (Orech et al., 2007). *Amaranthus hybridus* is cultivated in several regions of the world including South America, Africa and Asia (Dhellot et al., 2006). In Congo, *Amaranthus* leaves are eaten as green vegetables. In Nigeria, *Amaranthus* leaves combined with condiments are used to prepare soup as a rich source of nutrition (Ogwu, 2020). Similarly in Mozambique, *Amaranthus* leaves are boiled and mixed with a groundnut sauce are consumed as salad (Oliveira and de Carvalho, 1975). In West Africa, they are poured into a sauce and served over vegetables (Maiyo et al., 2010). Particularly, the leaves and seeds are applied as a poultice to treat swellings and infections, leaves are chewed to treat tooth ailments, powdered seeds are applied on insect stings, the root is used as an antidote for snakebites and to treat epilepsy, chest pain, constipation, and dysmenorrhoea; and unspecified plant parts are used as a sedative in tachycardia and against diverse pains (Lim, 2012).

The generated 67 locally sourced leafy vegetables were from 23 plant families (Table 2; Fig. 2). The most dominant plant families were Amaranthaceae (12 plant species), Asteraceae (7 plant species), Cucurbitaceae (8 plant species), Malvaceae (5 plant species) and Urticaceae (4 plant species). Amaranthaceae is recognized as one of the largest family of flowering plants. The dominance and frequent utilization of plants belonging to Amaranthaceae for nutritional and medicinal purposes remain common (Maroyi, 2020). In a previous study (Mokganya and Tshisikhawe, 2019), Amaranthaceae and Cucurbitaceae had the highest member of leafy vegetables with nutritional and medicinal properties. Several plants in the Amaranthaceae are recognized for their medicinal properties and highly valued by local communities. Ethnobotanical surveys conducted among these communities often reveal high popularity of plants within the Amaranthaceae in relation to their medicinal uses (Maroyi, 2020; Moyo and Aremu, 2022).

3.2.2. Utilization patterns for the leafy vegetables

For the leafy vegetables, the use of other plant parts such as seeds, stem, tubers, fruit, shoots, rhizomes and pods were recorded (Maanda and Bhat, 2010; Mbatha et al., 2022; Mokganya and Tshisikhawe, 2019). Relatively to the utilization of roots and stem, it is generally acknowledged that the leaves do not significantly impact life cycle of plants (Mokganya and Tshisikhawe, 2019). Furthermore, the preference for leaves as primary part in ethnobotanical studies may be attributed to their relatively availability and ease of harvesting.

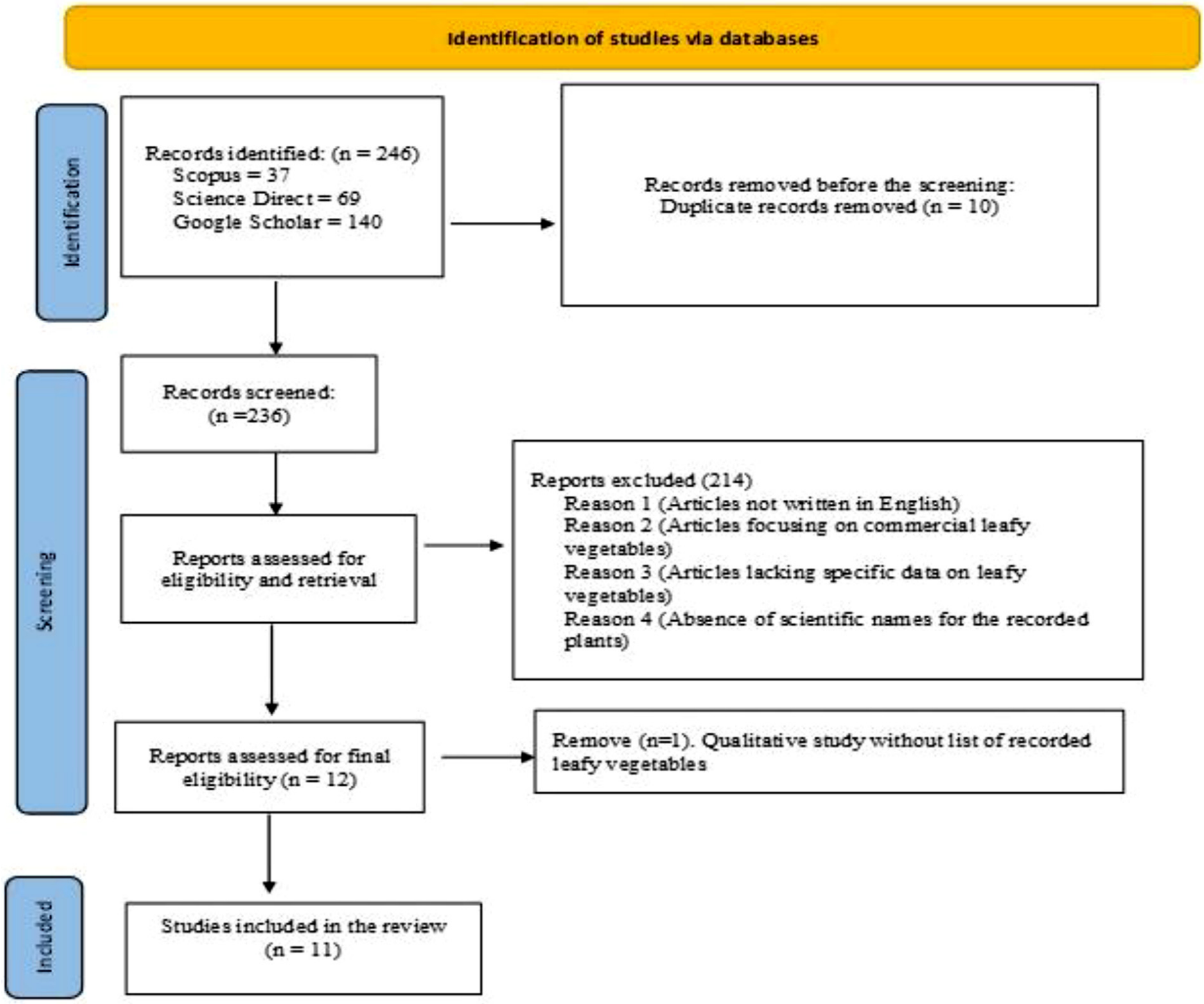

Fig. 1. Approach used for the screening and selection of articles on locally sourced leafy vegetables in South Africa (Jan 2010 to August 2023)

3.2.3. *Preparation methods for recorded leafy vegetables*

Various communities often apply their own unique way of preparing leafy vegetables. The leafy vegetables were often cooked/boiled (Table 2). Simple cooking often emerged as one of the frequently mentioned preparation method for leafy vegetables especially when it is intended to serve as a source of food and nutrition (Bvenura and Afolayan, 2014). This preparation method is often considered as the most preferred method due to its simplicity, requiring the addition of boiled water to the plant material. In this review, it was observed that some leafy vegetables are prepared singly and others in combination. For example, *Amaranthus thunbergii* and *Cleome gynandra*, are usually prepared singly while *Corchorus tridens, Momordica balsamina,* and *Corchorus tridens* are often cooked together. Existing literature indicate that cooking vegetables in combination can provide various health benefits, as the vegetables can complement each other nutritionally and medicinally (Singh, 2023). Similar observations were documented in Vhembe District, South Africa (Mokganya et al., 2019).

Mokganya et al. (2019) emphasized the importance of including detailed information on preparation methods in ethnobotanical studies. However, the current review identified a concerning gap in the availability of such information for some of the documented leafy vegetables. The absence of preparation method details can hinder the reliability of ethnobotanical research. Without details on how to prepare and use leafy vegetables for medicinal purposes, it becomes difficult for researchers to assess the biological efficacies as a means of substantiating the ethnobotanical information.

3.3. *Ethnobotanical uses of the leafy vegetables*

Ethnobotanical studies generally involve the gathering of information from local communities regarding traditional knowledge and practices. The recorded leafy vegetables served both nutritional and medicinal purposes among the local communities (Table 2). Generally, leafy vegetables are known to offer numerous health benefits due to their unique chemical compositions. In addition, the medicinal properties of leafy vegetables contribute significantly to maintaining good health and well-being in rural areas where access to conventional medical care is often limited. By harnessing the medicinal properties of leafy vegetables, there is potential to gain valuable insights and develop new treatments (Mashabela and Otang-Mbeng, 2021). Despite acknowledging the medicinal potential of leafy vegetables and their role in rural healthcare, relevant empirical data is required to confirm their efficacy and safety for medicinal purposes. Without such evidence, the reliability and effectiveness of these medicinal uses remain anecdotal.

3.3.1. *Applications in folk medicine*

In South Africa, the use of leafy vegetables for their medicinal value are deeply rooted in traditional knowledge and practices

Table 1
Overview of literature documenting the ethno-botanical uses of locally sourced leafy vegetables in South Africa from 2010 to 2023

Author (Year)	Title of the study	Province	Ethnic group	No. of plants	No. of families	Plants selection criteria	Participant type	Methodological framework
Bvenura and Afolayan (2014)	'Ethnobotanical survey of wild vegetables in Mbashe and Nkonkobe municipalities, Eastern Cape Province, South Africa'	Eastern Cape	Xhosa	22	12	Unspecified	Older women	Well-structured questionnaire and interviews
Kwinana-Mandindi (2014)	'An ethnobotanical survey of wild vegetables in the Amathole district, Eastern Cape Province, South Africa'	Eastern cape	Xhosa	25	16	Food and medicinal uses	Males and females	Structured and semi-structured questionnaires, Focus groups and Interview schedule
Maanda and Bhat (2010)	'Wild vegetable use by Vhavenda in the Venda region of Limpopo Province, South Africa'	Limpopo	Venda	40	20	Unspecified	Older women	Unspecified
Maroyi (2020)	'Ethnobotanical study of wild and cultivated vegetables in the Eastern Cape Province, South Africa'	Eastern Cape	Xhosa	32	15	Unspecified	Home garden holders	Interviews and field surveys
Maroyi (2022)	'Traditional food plants cultivated and managed in home gardens in the Eastern Cape Province'	Eastern Cape	Xhosa	58	29	Unspecified	Household farmers	Questionnaire, personal observations and guided field walks
Mashabela and Otang-Mbeng (2021)	'Ethnobotanical survey of indigenous leafy vegetables in Ehlanzeni District of the Mpumalanga Province, South Africa'	Mpumalanga	Swati	17	10	Medicinal and nutritional uses of indigenous leafy vegetables	Older women	Interviews
Mathibela and Potgieter (2017)	'Leafy vegetables consumed by indigenous people in Blouberg, Limpopo'	Limpopo	Bapedi	4	Unspecified	Unspecified	Small-scale Farmers	Interviews
Mbatha et al. (2022)	'Potential of domesticating the underutilized multipurpose wild leafy vegetable, *Sesamum alatum*, under low input organic cropping systems'	Unspecified	Zulu	1	1	Nutritional and medicinal uses	Unspecified	Unspecified
Mokganya and Tshisikhawe (2019)	'Medicinal uses of selected wild edible vegetables consumed by Vhavenda of the Vhembe District Municipality, South Africa'	Limpopo	Venda	14	10	Medicinal uses	Youth and elders	Semi-structured questionnaire and interviews
Mokganya et al. (2019)	'Indigenous preparation and preservation methods of selected indigenous wild vegetables of Vhembe District'	Limpopo	Venda	10	6	Preparation and preservation of wild edible vegetables	Randomly selected individuals	Semi-structured interview
Ngcaba and Maroyi (2021)	'Home gardens in the Eastern Cape Province, South Africa: A promising approach to enhance household food security and well-being'	Eastern Cape	Xhosa	27	18	Edible plants grown and maintained in home gardens	Randomly selected individuals	Participatory rural appraisal (PRA) methods

(Mokganya et al., 2019). These leafy vegetables are known for their therapeutic value among various ethnic groups in South Africa. These traditional remedies are highly valued and often play an important role in the primary healthcare and well-being of people in rural communities (Aremu et al., 2021). Many rural areas have easy access to these plants, which contributes to their widespread use. However, most of the studies conducted on this topic found that the most common diseases treated with medicinal plants were non-infectious such as diabetes, cancer, and blood pressure (Sofowora et al., 2013). From the leafy vegetables uncovered in this review, about 29 % are used for prevention, treatment, or management of various ailments (Table 2). The most mentioned health conditions for which the leafy vegetables were utilized for included digestive disorders, skin conditions, blood pressure, infertility, and diabetes. For instance, members of the Amaranthaceae had the highest number of citations and the leaves have been utilized for various purposes such as relieving pains, inducing labour, reducing fever, promoting digestion, acting as a laxative, and lowering blood sugar (Ruth et al., 2021). Additionally, leafy vegetables have demonstrated anti-inflammatory, antibacterial, antioxidant, and antimalarial effects (Bvenura and Afolayan, 2014). Likewise, a study conducted in Limpopo revealed that the frequent consumption of *Bidens pilosa* (muvhuyu) was used to alleviate ear infections and treat inflammations (Mokganya and Tshisikhawe, 2019). Intriguingly, some of these leafy vegetables are commonly consumed as potherbs. Regular consumption of *Cleome gynandra* (murudi) during pregnancy can help reduce labour pains and help with stimulation of milk production when breastfeeding (Moyo and Aremu, 2022). These findings highlight the diverse medicinal properties and potential health benefits associated with locally sourced leafy vegetables in South Africa.

3.3.2. Uses as a source of food and nutrition as well as sustainable livelihood

Locally available leafy vegetables have played a crucial role in ensuring that households have enough food and a sustainable livelihood. Indigenous farmers and communities have relied on these leafy vegetables for food and nutrition security (Omotayo and Aremu, 2020). Raising awareness on the benefits associated with the consumption of leafy vegetables can potentially help address food insecurity and malnutrition in rural communities. Particularly, leafy vegetables are regarded as a primary source of livelihood for indigenous households (Maroyi, 2022). Multiple studies have shown that leafy vegetables are commonly used for various purposes, especially as a food source (Mungofa et al., 2022). A similar study in the Eastern Cape Province of South Africa found that many people depend on leafy vegetables to meet their food and nutritional needs, which helps to address malnutrition (Jansen van Rensburg et al., 2004). By cultivating these vegetables in their gardens, households were able

Table 2
Ethnobotanical information of leafy vegetables with documented ethnobotanical uses in South Africa. Botanical names were verified using WFO, 2024 (World Flora Online: http://www. worldfloraonline.org/). #Status: Based on the South African Red Data List (http://redlist.sanbi.org/, accessed 20/06/2024)

Scientific name	Plant family	Local/common names	#Status	Preparation	Uses	References
1. *Abelmoschus esculentus* Moench	Malvaceae	Delele Mandande, Lady's fingers	Naturalized exotic	Unspecified	Medicine (cooked leaves and fruit pulp eaten as potherb which helps in relieving constipation)	(Mokganya and Tshisikhawe, 2019)
		Delelemandande		Cooking	Food (leaves are hard, but when combined with other vegetables and cooked they become more palatable)	(Maanda and Bhat, 2010)
		Mandade		Unspecified	Food	(Mashabela and Otang-Mbeng, 2021)
2. *Adenia digitata* (Harv.) Engl.	Passifloraceae	Dundu	Not endemic	Cooking	Food	(Maanda and Bhat, 2010)
3. *Amaranthus blitum* L (*Amaranthus blitum* subsp. *oleraceus* (L). Costea)	Amaranthaceae	Unomdlomboyi	Not endemic	Unspecified	Unspecified	(Bvenura and Afolayan, 2014)
4. *Amaranthus blitoides* S. Watson	Amaranthaceae	Amaranthaceae	Naturalized exotic	Cooking	Food (Fresh leaves are cooked with onions and tomatoes and served with pap, mashed pumpkins, rice or bread)	(Bvenura and Afolayan, 2014)
5. *Amaranthus dubius* Mart ex thell	Amaranthaceae	Vowa, spleen amaranth	Naturalized exotic	Unspecified	Unspecified	(Mokganya and Tshisikhawe, 2019)
		Vowa, smooth pigweed		Unspecified	Unspecified	(Maanda and Bhat, 2010)
		Utyuthu, Imbuya		Cooking	Leaves and young stem combined with maize meal, useful for medicinal reasons-lower blood sugar if eaten raw	(Kwinana-Mandindi, 2014)
6. *Amaranthus cruentus* L. (*Amaranthus esculentus* Besser)	Amaranthaceae	Mugango, red amaranth	Naturalized exotic	Unspecified	Medicine (relieves constipation and, as an effective remedy for ulcers and promoting joint health)	(Mokganya and Tshisikhawe, 2019)
		Gango, purple amaranth		Unspecified	Tender stem and leaves are used as relish; sometimes mixed with other vegetables including tender pumpkin leaves	(Maanda and Bhat, 2010)
7. *Amaranthus hybridus* L.	Amaranthaceae	Thebe	Naturalized exotic	Unspecified	Unspecified	(Mokganya and Tshisikhawe, 2019)
		Nomdllomboyi		Unspecified	Food	(Maroyi, 2022)
		Nomdllomboyi		Unspecified	Unspecified	(Mashabela and Otang-Mbeng, 2021)
		Unomdlomboyi		Unspecified	Medicine (aid digestion, improve eyesight, prevent constipation, promote healthy bone)	(Bvenura and Afolayan, 2014)
		Nomdlomboyi		Unspecified	Unspecified	(Ngcaba and Maroyi, 2021)
		Thebe		Cooking	Food	(Maanda and Bhat, 2010)
8. *Amaranthus spinosus* L.	Amaranthaceae	Utyuthu	Naturalized exotic	Unspecified	Food	(Maroyi, 2022)
		Mukhuluvhali		Unspecified	Unspecified	(Mokganya and Tshisikhawe, 2019)
		Mukuluvhali		Unspecified	Unspecified	(Maanda and Bhat, 2010)
9. *Amaranthus thunbergii* Moq.	Amaranthaceae	Unspecified	Not endemic	Cooking	Food	(Mathibela and Potgieter (2017)
10. *Amaranthus* L	Amaranthaceae	Imbuya	Not verified as the plant was not identified to species level in the original article	Unspecified	Unspecified	(Mashabela and Otang-Mbeng, 2021)
11. *Beta vulgaris* L.	Amaranthaceae	Macembe abeetroot	Naturalized exotic	Cooking	Unspecified	(Mashabela and Otang-Mbeng, 2021)
		Bhettruthi		Cooking	Food	(Maroyi, 2022)
12. *Bidens pilosa* L. (*Bidens pilosa* var. *leucantha* (L.) Harvey)	Asteraceae	Mushidzhi	Naturalized exotic	Cooking	Unspecified	(Mokganya and Tshisikhawe, 2019)
		Mushidzhi		Unspecified	Unspecified	(Maanda and Bhat, 2010)
		Muvhuyu		Unspecified	Medicine (as an ear drops to relief earache and treat inflammation, digestive disorder, cancer, and wounds)	(Mokganya and Tshisikhawe, 2019)
		Umhllabangulo, ucadollo		Unspecified	Food	(Maroyi, 2022)
		Unspecified		Unspecified	Unspecified	(Mashabela and Otang-Mbeng, 2021)
		Umhllabangulo		Unspecified	Unspecified	(Maroyi, 2020)
		Umhllabangulo		Unspecified	Unspecified	(Ngcaba and Maroyi, 2021)
		Amalanjane		Unspecified	Unspecified	(Kwinana-Mandindi, 2014)

(*continued*)

Table 2 (*Continued*)

Scientific name	Plant family	Local/common names	#Status	Preparation	Uses	References
13. *Brassica oleracea* L.	Brassicaceae	Makhovu	Naturalized exotic	Unspecified	Unspecified	(Mokganya and Tshisikhawe, 2019)
		Ikhaphetshu		Unspecified	Food	(Maroyi, 2022)
14. *Brassica rapa* L.	Brassicaceae	Unspecified	Naturalized exotic	Leaves and roots cooked as vegetables	Food	(Ngcaba and Maroyi, 2021)
		Turnip		Unspecified	Food	(Maroyi, 2020)
15. *Brassica* spp.	Brassicaceae	Unspecified	Naturalized exotic	Unspecified	Livelihood	(Maroyi, 2020)
16. *Bryonia alba* L.	Cucurbitaceae	Shubaba	Naturalized exotic	Unspecified	Medicine	(Mashabela and Otang-Mbeng, 2021)
17. *Catha edulis* (Vahl) Forssk. ex Endl. (*Catha edulis* (Vahl.) Endl.)	Celastraceae	Iqwaka	Not endemic	Unspecified	Food	(Maroyi, 2022)
		Iqwaka		Unspecified	Unspecified	(Maroyi, 2020)
18. *Centella coriacea* Nannf.	Apiaceae	Unongottyozana	Endemic	Unspecified	Food	(Maroyi, 2022)
		Unongotyozana		Unspecified	Unspecified	(Maroyi, 2020)
		Unongotyozane		Tender and fresh leaves are boiled in water	Medicine (antioxidant, anti-inflammatory)	(Bvenura and Afolayan, 2014)
19. *Chenopodium album* L (*Chenopodium album* var. *viride* (L.) Pursh)	Amaranthaceae	Imbikicane	Naturalized exotic	Unspecified	Unspecified	(Maroyi, 2020)
		Imbikicaneebomvu		Unspecified	Medicine (improves appetite, acts as laxative)	(Bvenura and Afolayan, 2014)
		Iphunga		Unspecified	Food	(Maroyi, 2022)
		Daledale, goosefoot		Unspecified	Food	(Mokganya and Tshisikhawe, 2019)
		Imbilikocane, fat hen		Cooked or fried	Food (leaves and young stem are combined with maize meal)	(Kwinana-Mandindi, 2014)
20. *Chenopodium murale* L.	Amaranthaceae	Umfanuthenkqi	Naturalized exotic	Unspecified	Medicine (as contraceptive)	(Bvenura and Afolayan, 2014)
21. *Citrullus lanatus* (Thunb.) Matsum. & Nakai	Cucurbitaceae	Umbhidvo wetintsanga	Not endemic	Unspecified	Medicine	(Mashabela and Otang-Mbeng, 2021)
		Ikhaphetshu		Unspecified	Source of livelihood (grown to sell)	(Maroyi, 2022)
		Ikhaphetshu		Leaves cooked as vegetables	Food	(Ngcaba and Maroyi, 2021)
22. *Cleome gynandra* L.	Cleomaceae	Murudi	Not endemic	Unspecified	Medicine (reduce blood pressure and stimulate milk production)	(Mokganya and Tshisikhawe, 2019)
		Murudi, Muruthu		Unspecified	Unspecified	(Maanda and Bhat, 2010)
		Murudi		Cooking	Unspecified	(Mokganya et al., 2019)
		Unspecified		Cooking	Food	(Mathibela and Potgieter, 2017)
		Bangani		Unspecified	Medicine	(Mashabela and Otang-Mbeng, 2021)
23. *Cleome monophylla* L. (*Cleome monophylla* var. *madagascariensis* Hadj-Moust)	Cleomaceae (Capparaceae)	Mutohotoho	Not endemic	Unspecified	Unspecified	(Maanda and Bhat, 2010)
		Mutohotoho		Cooking	Unspecified	(Mokganya et al., 2019)
24. *Colocasia esculenta* (L.) Schott (*Colocasia antiquorum* var. *esculenta* (L.) Schott)	Araceae	Mufhongwe	Not endemic	Unspecified	Food	(Maanda and Bhat, 2010)
		Mathapa		Unspecified	Unspecified	(Mashabela and Otang-Mbeng, 2021)
		Amagqabi edumbe		Cooking	Food (consumed like potatoes, leaves in small amounts can be mixed with imifino)	(Kwinana-Mandindi, 2014)
25. *Corchorus tridens* L. (*Corchorus tridens* var. *euryphyllus* Domin)	Malvaceae	Unspecified	Naturalized exotic	Leaves are cooked with bicarbonate of soda	Unspecified	(Mathibela and Potgieter, 2017)
		Delele		Unspecified	Unspecified	(Maanda and Bhat, 2010)
26. *Cucurbita pepo* L.	Cucurbitaceae	Phuri	Not endemic	Cooking	Unspecified	(Mokganya et al., 2019)
		Thanga		Cooking	Food	(Maanda and Bhat, 2010)
27. *Cucumis africanus* L. f.	Cucurbitaceae	Tshinyagu	Not endemic	Cooking	Unspecified	(Maanda and Bhat, 2010)
28. *Cynanchum insipidum* (E.Mey.) Liede & Khanum (*Pentarrhinum insipidum* E. Mey.)	Apocynaceae	Phulule	Not endemic	Unspecified	Food	(Maanda and Bhat, 2010)
29. *Foeniculum vulgare* Mill.	Apiaceae	Imboziso	Naturalized exotic	Unspecified	Food	(Maroyi, 2022)

(*continued*)

Table 2 (*Continued*)

Scientific name	Plant family	Local/common names	#Status	Preparation	Uses	References
30. *Galinsoga parviflora* Cav.	Asteraceae	Iindevu zomlungu	Naturalized exotic	Cooking	Food (Fresh and young leaves are cut and mixed with other wild vegetables, boiled, spices are added and cooked until done)	(Bvenura and Afolayan, 2014)
31. *Grewia occidentalis* L.	Malvaceae (Tiliaceae)	Mulembu	Not endemic	Unspecified	Unspecified	(Maanda and Bhat, 2010)
32. *Hibiscus trionum* L.	Malvaceae	Delelemukhwayo	Not endemic	Unspecified	Unspecified	(Maanda and Bhat, 2010)
33. *Ipomoea batatas* (L.) Lam.	Convolvulaceae	Murambo	Not endemic	Cooking	Food	(Maanda and Bhat, 2010)
		Murambo		Unspecified	Unspecified	(Mokganya et al., 2019)
		Macembe abhatata		Unspecified	Unspecified	(Mashabela and Otang-Mbeng, 2021)
34. *Ipomoea obscura* (L.) Ker Gawl. (*Convolvulus obscurus* L.)	Convolvulaceae	Muduhwi	Not endemic	Unspecified	Unspecified	(Maanda and Bhat, 2010)
35. *Lactuca sativa* L. (*Lactuca dregeana* L.)	Asteraceae	Ilethasi	Endemic	Unspecified	Source of livelihood (grown to sell)	(Maroyi, 2020)
36. *Lagenaria siceraria* (Molina) Standl.	Cucurbitaceae	Muphapha	Not endemic	Unspecified	Medicine (relieve period pains)	(Mokganya and Tshisikhawe, 2019)
		Mbhidvo		Unspecified	Unspecified	(Mashabela and Otang-Mbeng, 2021)
37. *Malva parviflora* L. (*Malva parviflora* var. *parviflora*)	Malvaceae	Tshiteaduvha	Naturalized exotic	Unspecified	Food	(Maanda and Bhat, 2010)
38. *Manihot esculenta* L.	Euphorbiaceae	Umjumbula	Naturalized exotic	Unspecified	Unspecified	(Mashabela and Otang-Mbeng, 2021)
39. *Momordica balsamina* L.	Cucurbitaceae	Tshibavhe	Not endemic	Unspecified	Medicine (stabilize blood and sugar levels and poultice for burns and treat diabetes)	(Mokganya and Tshisikhawe, 2019)
		Tshibavhe		Unspecified	Food	(Maanda and Bhat, 2010)
		Inkaka		Unspecified	Medicine (stomach pains, vomiting associated with bile and fever)	(Mashabela and Otang-Mbeng, 2021)
40. *Momordica charantia* L. (*Momordica charantia* Descourt)	Cucurbitaceae	Mutshatshamabunyu	Naturalized exotic	Bitter leaves are cooked with other wild vegetables	Food	(Maanda and Bhat, 2010)
		Lugu		Unspecified	Medicine (stabilize blood and sugar levels, anti-HIV, anti-ulcer, anti-inflammatory)	(Mokganya and Tshisikhawe, 2019)
41. *Momordica foetida* Schumach	Cucurbitaceae	Nngu	Not endemic	Unspecified	Food	(Maanda and Bhat, 2010)
		Nngu		Unspecified	Unspecified	(Mokganya et al., 2019)
42. *Nicandra physalodes* (L.) Gaertn.	Solanaceae	Tshirunngudane	Naturalized exotic	Unspecified	Food	(Maanda and Bhat, 2010)
43. *Obetia tenax* (N.E. Br) Friis	Urticaceae	Muvhazwi	Not endemic	Unspecified	Food	(Maanda and Bhat, 2010)
44. *Oxygonum dregeanum* Meisn	Polygonaceae	Muthanya	Not endemic	Unspecified	Medicine (hypertension and diabetes)	(Maanda and Bhat, 2010)
45. *Phaseolus vulgaris* L	Fabaceae	Bontshisi	Cultivated species/garden escape	Unspecified	Unspecified	(Mashabela and Otang-Mbeng, 2021)
46. *Portulaca oleracea* L	Portulacaceae	Igwannisha	Naturalized exotic	Unspecified	Food	(Maroyi, 2020)
47. *Portulacaria afra* Jacq	Didiereaceae	Igwanitsha	Not endemic	Unspecified	Unspecified	(Maroyi, 2020)
		Igwanitsha		Unspecified	Food	(Maroyi, 2022)
48. *Pouzolzia mixta* Solms (*Pouzolzia mixta* var. *mixta*)	Urticaceae	Muthanzwa	Not endemic	Unspecified	Food	(Maanda and Bhat, 2010)
49. *Rumex lanceolatus* Thunb.	Polygonaceae	Idololenkonyane	Not endemic	Unspecified	Unspecified	(Maroyi, 2020)
50. *Sesamum alatum* Thonn.	Pedaliaceae	Unspecified	Not endemic	Cooking	Medicine (treat constipation, male infertility, fungal and bacterial infections)	(Mbatha et al., 2022)
51. *Sesamum zanguebarium* (Lour.) Byng & Christenh. (*Dicerocaryum zanguebaricum* (Lour.) Merr.)	Pedaliaceae	Museto	Not endemic	Unspecified	Unspecified	(Maanda and Bhat, 2010)
52. *Solanum nigrum* L.	Solanaceae	Umsobosobo/ Unongotyozana/	Naturalized exotic	Leaves mixed with other leaves to prepare imifino	Food	(Kwinana-Mandindi, 2014)
		Umsobo		Unspecified	Unspecified	(Maroyi, 2020)
53. *Solanum retroflexum* Dunal	Solanaceae	Muxe	Not endemic	Unspecified	Food	(Maanda and Bhat, 2010)
		Umsobowehlathi		Unspecified	Unspecified	(Maroyi, 2020)
		Muxe		Unspecified	Medicine (treat earache in children)	(Mokganya and Tshisikhawe, 2019)
54. *Sonchus asper* (L.) Hill	Asteraceae	Irwabe	Naturalized exotic	Unspecified	Food	(Maroyi, 2022)
		Rwabe		Unspecified	Unspecified	(Maroyi, 2020)
		Shashe		Unspecified	Food	(Maanda and Bhat, 2010)

(*continued*)

Table 2 (*Continued*)

Scientific name	Plant family	Local/common names	#Status	Preparation	Uses	References
55. *Sonchus dregeanus* DC	Asteraceae	Irhwabe (utsolwane)	Not endemic	Combined with other leaves to make imifino	Food	(Kwinana-Mandindi, 2014)
56. *Sonchus oleraceus* L.	Asteraceae	Ihlaba	Naturalized exotic	Unspecified	Unspecified	(Maroyi, 2020)
		Ingabe		Unspecified	Unspecified	(Mashabela and Otang-Mbeng, 2021)
57. *Spinacia oleracea* L.	Amaranthaceae	Imifuno	Not endemic	Leaves cooked as vegetables or made into salad	Food	(Ngcaba and Maroyi, 2021)
		Imifuno		Unspecified	Food	(Maroyi, 2022)
		Imifuno		Unspecified	Food	(Maroyi, 2020)
58. *Taraxacum officinale* Weber	Asteraceae	Uqudalele	Naturalized exotic	Unspecified	Unspecified	(Maroyi, 2020)
		Ikhokhhoyi		Unspecified	Food	(Maroyi, 2020)
59. *Tragia* spp.	Euphorbiaceae	Mbuwambuwane	Not endemic	Unspecified	Medicine (skin conditions and diabetes)	(Maanda and Bhat, 2010)
60. *Trema orientalis* (L.) Blume (*Celtis orientalis* L.)	Cannabaceae (Ulmaceae)	Mukurukuru	Not endemic	Cooking	Food	(Maanda and Bhat, 2010)
61. *Tribulus terrestris* L.	Zygophyllaceae	Tsetwana	Not endemic	Unspecified	Medicine (treat infertility, low sex drive and erectile dysfunction)	(Maanda and Bhat, 2010)
62. *Tribulus zeyheri* Sond.	Zygophyllaceae	Tseto	Not endemic	Unspecified	Unspecified	(Maanda and Bhat, 2010)
63. *Tropaeolum majus* L.	Tropaeolaceae	Bopa	Not endemic	Unspecified	Unspecified	(Maanda and Bhat, 2010)
64. *Urtica dioica* L.	Urticaceae	Dzaluma	Naturalized exotic	Cooking	Food	(Maanda and Bhat, 2010)
65. *Urtica lobulata* Blume	Urticaceae	Urhawu/Urhalijane	Not endemic	Leaves mixed with other leaves to prepare "*imifino*"	Food, medicine (reduce inflammation, fever, and blood pressure)	(Kwinana-Mandindi, 2014)
66. *Vigna unguiculata* (L.) Walp.	Fabaceae	Unspecified	Not endemic	Unspecified	Unspecified	(Mashabela and Otang-Mbeng, 2021)
		Unspecified		Cooking	Unspecified	(Mathibela and Potgieter, 2017)
		Munawa		Unspecified	Medicine (treat stomach problems and roots are used to treat epilepsy, chest pain and dysmenorrhoea)	(Mokganya and Tshisikhawe, 2019)
		Munawa		Cooking	Unspecified	(Maanda and Bhat, 2010)
		Unspecified		Cooking	Unspecified	(Mathibela and Potgieter, 2017)
		Munawa		Cooking	Unspecified	(Mokganya et al., 2019)
67. *Zantedeschia aethiopica* (L.) Spreng	Araceae	Inyibiba	Not endemic	Unspecified	Food, medicine	(Kwinana-Mandindi, 2014)

to improve their access to healthy food. For instance, the Vhavenda community of Limpopo Province in South Africa relied on leafy vegetables because they were easily available and affordable. In addition, leafy vegetables are included in their diets to afford the households variety and reduce the risk of food and nutrition insecurity (Maanda and Bhat, 2010). A study conducted in Eastern Cape Province emphasized the value of wild leafy vegetables in ensuring household food and nutrition security (Kwinana-Mandindi, 2014). The accessibility and cultural significance of these leafy vegetables made them a preferred choice for local communities. Likewise, the utilization of local leafy vegetables provides food-nutrition and enhances the preservation of traditional knowledge and practices related to food security (Imathiu, 2021). This finding underscores the importance of recognizing and supporting indigenous food systems to enhance the food and nutrition security of households (Masango and Mbarika, 2022).

3.4. Nutritional profiles of the recorded leafy vegetables

Leafy vegetables especially the underutilized ones often offer superior nutritional benefits, rich in essential nutrients such as dietary fiber, vitamins, and minerals, surpassing some commercial vegetables (Moyo et al., 2018). They serve as source of protein, beta carotene, vitamin C, fiber, calcium, iron, and zinc (Table 3). The leaves of *Solanum nigrum, Amaranthus hybridus* and *Brassica rapa* contained appreciable amount (46–80 mg/100 g) of vitamin C (ascorbic acid) except those for *Corchorus tridens* and *Chenopodium murale* whose values were below the recommended standard value of 40 mg/day (FAO, 2001). *Amaranthus hybridus* are rich in vitamins C and their regular consumption has the potential to improve eyesight, bone health and skin elasticity. They are abundant sources of vitamins (vitamin A, D, E, K) (Arasaretnam et al., 2018). Leafy vegetables are recognized as one of the richest and cheapest sources of proteins. For example, *Adenia digitata* is a valuable high-protein leafy vegetable (Uusiku et al., 2010). Proteins play a critical role in cellular functions, structure and regulations of metabolic activities in all living organisms. Its nutritional quality is determined by the proportions of essential amino acids, which cannot be synthesized by humans and hence must be provided in the diet.

Nevertheless, comparing locally sourced leafy vegetables to the commonly consumed cultivated varieties reveals their unique diversity in micronutrients and phytochemicals. While *Spinacia oleracea* and *Brassica oleracea* are well-known for their nutritional value, underutilized leafy vegetables including *Adenia digitata* exemplify the richness of underutilized vegetables, often containing higher levels of certain nutrients.

3.5. Biological effects and phytochemicals of the leafy vegetables

In South Africa, the locally sourced leafy vegetables possess a wide range of bioactive compounds, which are associated with various biological activities and potential health benefits (Table 4). Additionally, the phytochemical profiles revealed the presence of various bioactive compounds such as polyphenols, flavonoids, and carotenoids in the locally sourced leafy vegetables (Table 4). Specifically, *Brassica* spp and *Chenopodium murale* are examples of leafy vegetables with a rich pool of phytochemicals. Flavonoids in the leafy vegetables exert their biological activities through several mechanisms. For instance, flavonoids can act as antioxidants by scavenging free radicals and

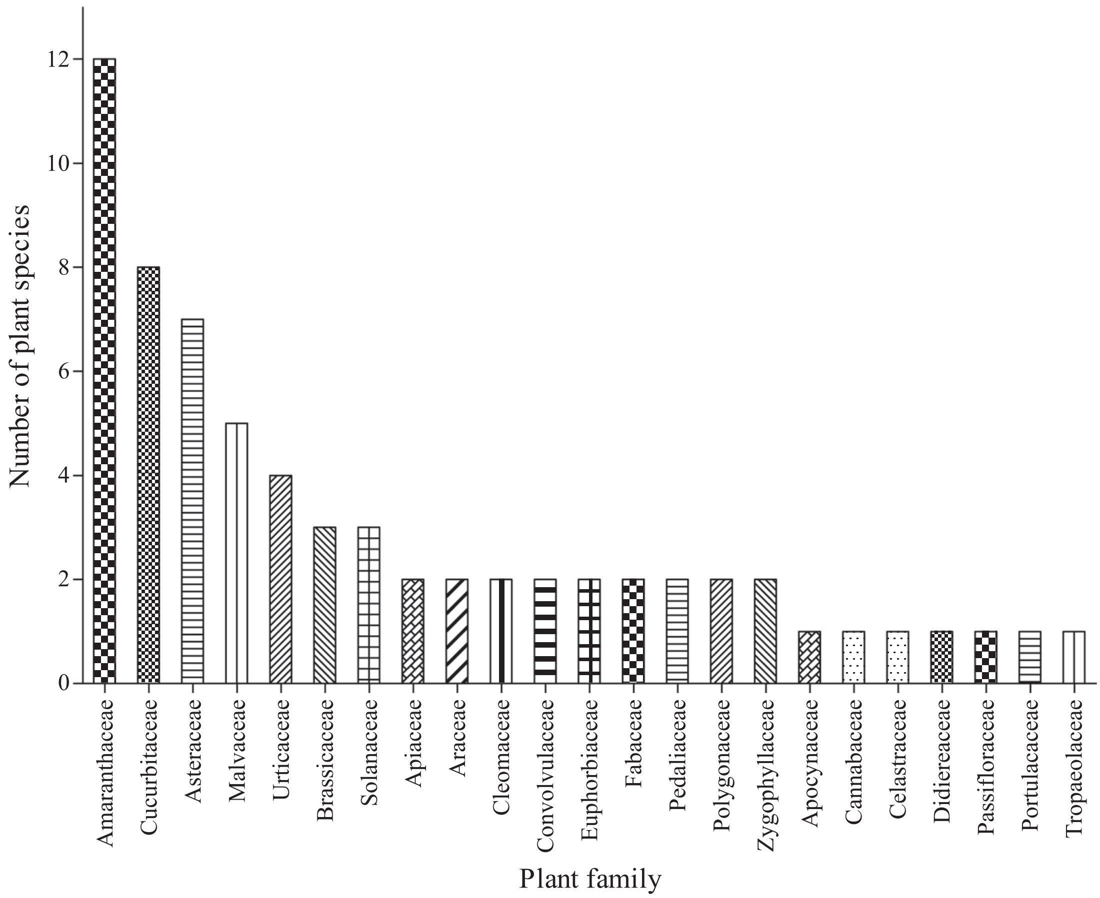

Fig. 2. A representation of 23 plant families with ethnobotanical uses of locally sourced leafy vegetables in South Africa

chelating metal ions, thus preventing oxidative stress and cellular damage (Pateiro et al., 2023). Generally, flavonoids have been extensively studied for their antioxidant and anti-inflammatory properties, which can help protect against chronic diseases such as cancer, cardiovascular diseases, and neuro degenerative disorders (Oyedemi et al., 2011). Albeit the presence of flavonoids in these vegetables suggests their potential as natural sources of antioxidants and anti-inflammatory agents. Particularly, a significant number of the leafy vegetables exerted anti-diabetic and antimicrobial properties (Table 4).

In addition to flavonoids, other bioactive compounds with various biological activities have been reported. For example, some of these leafy vegetables are known to be rich in carotenoids, which are potent antioxidants and play a crucial role in promoting good sight and preventing oxidative damage to the retina (Ndawonde, 2020). Thus, the consumption of these leafy vegetables can provide a natural source of carotenoids, potentially reducing the risk of age-related macular degeneration and other eye-related conditions (Fiedor and Burda, 2014).

Furthermore, locally available leafy vegetables may contain other yet-to-be-explored bioactive compounds that could exhibit antimicrobial, anti-diabetic, anti-inflammatory, or other health-promoting properties (Mulaudzi et al., 2020). However, further research is needed to uncover the full range of biological activities and health benefits associated with these plants. Incorporating these leafy vegetables into the diet can contribute to a varied and nutrient-rich eating pattern, potentially promoting good health and well-being.

In addition, compounds such as tannins and flavonoids have antimicrobial properties, potentially by binding to and inactivating microbial enzymes or by disrupting microbial membranes and is toxic to filamentous fungi, yeast and bacteria (Ejoh et al., 2007). Flavonoids provide protection against diseases such as cancer, inflammation, atherosclerosis, ischaemic injury, and neuro degenerative diseases (Onyeka and Nwambekwe, 2007). Saponins have hypocholesterolemic effect which may contribute to lowering cholesterol levels by binding to bile acids and cholesterol, thus preventing their absorption in the body (James and Matemu, 2016).

3.6. Influence of cultural and socio-economic factors on the promotion and utilization of leafy vegetables

Cultural factors deeply influence the cultivation and utilization of locally available leafy vegetables, as they are intertwined with traditional practices and knowledge passed down through generations. Additionally, some leafy vegetables hold ceremonial importance and symbolize resilience, nature connection, or cultural identity, strengthening community bonds. From a socioeconomic perspective, these leafy vegetables significantly contribute to food security, especially in rural areas, offering nutrition-dietary diversity year-round and serving as a cost-effective option for households and income source for marginalized groups through local cultivation and trade (Schreinemachers et al., 2018). Despite their perceived health benefits and resilience to local climates, challenges such as stigma and insufficient information regarding plant parts used hinder broader acceptance. Recognizing the value of leafy vegetables and addressing these challenges are crucial for enhancing food security and livelihoods in disadvantaged communities (Qwabe and Pittawaty, 2023).

Among the 67 leafy vegetables, the majority were considered as not endemic (53.7 %, 36 plant species) and naturalized exotic (41.7 %, 28 plant species), while the endemic (2.9 %, 2 plant species) and

Table 3
Examples of the nutritional constituents of locally sourced leafy vegetables in South Africa. #Vit = vitamin. Values are reported in terms of fresh weight. NR – no record found

Scientific name	Energy KJ (kcal)	Protein (g/100 g)	Beta carotene (mg)	#Vit. C (mg/100 g)	Fibre (g/100 g)	Calcium (mg/100 g)	Iron (mg/100 g)	Zinc (mg/100 g)	Reference
1. *Abelmoschus esculentus* Moench	50.57	3.55	0.83	NR	8.2	266	1.6	2.0	(Romdhane et al., 2020)
2. *Adenia digitata* (Harv.) Engl.	69	4	NR	52	3	410	NR 9.3	NR 1.8	(Uusiku et al., 2010); (Osman, 2004)
3. *Amaranthus blitum* L (*Amaranthus blitum* subsp. *oleraceus* (L). Costea)	NR	NR	NR	NR	NR	NR	NR	NR	NR
4. *Amaranthus blitoides* S. Watson	NR	NR	NR	NR	NR	NR	NR	NR	NR
5. *Amaranthus dubius* Mart ex thela	49	10.57	NR	46–126	53.85	509.05	0.7134	14.46	(Anju et al., 2022)
6. *Amaranthus cruentus* L. (*Amaranthus esculentus* Besser)	40.0	1.13	0.21	2.4	3.08	0.94	0.46	0.36	(Nesamvuni et al., 2001)
7. *Amaranthus hybridus* L.	53	6	3.29	25.40	2.81	2363	21	18	(Odhav et al., 2007); (Akubugwo et al., 2007)
8. *Amaranthus spinosus* L.	27	4	NR	NR	2.48	3931	32	15	(Odhav et al., 2007)
9. *Amaranthus thunbergii* Moq.	NR	NR	NR	NR	NR	NR	NR	NR	NR
10. *Amaranthus* L	27–53	4–6	NR	46–126	3	253–425	0.3–3.8	0.02–8.4	(Uusiku et al., 2010)
11. *Beta vulgaris* L.	175	13.23	NR	NR	2.56	13.82	0.76- 1.40	0.29- 1.26	(Iwuozor and Afiomah, 2020)
12. *Bidens pilosa* L. (*Bidens pilosa* var. *leucantha* (L.) Harvey)	39	5	NR	NR	2.92	1354	17	22	(Odhav et al., 2007)
13. *Brassica oleracea* L.	24	9.9	NR	33	0.7	52	NR	0.13	(Shackleton et al., 2009)
14. *Brassica rapa* L.	16	2.2	NR	30–113	1.5	210	0.31	0.2	(Shackleton et al., 2009)
15. *Brassica* spp.	NR	NR	0.81	52.9	NR	1057	18.11	0.66	(Bwembya et al., 2018; Singh et al., 2007)
16. *Bryonia alba* L.	NR	NR	NR	NR	NR	NR	NR	NR	NR
17. *Catha edulis* (Vahl) Forssk. ex Endl.	NR	NR	NR	NR	NR	NR	NR	NR	NR
18. *Centella coriacea* Nannf.	NR	2.4	3.9	48.5	1.6	174	14.86	11.3	(Chandrika and Kumara, 2015)
19. *Chenopodium album* L (*Chenopodium album* var. *viride* (L.) Pursh)	59	5	9.54	80	1.92	1490	13	109	(Odhav et al., 2007)
20. *Chenopodium murale* L.	NR	4.76	NR	0.117	1.35	11.34	0.59	0.14	(Bvenura and Afolayan, 2014)
21. *Citrullus lanatus* (Thunb.) Matsum. & Nakai	NR	NR	NR	NR	NR	NR	NR	NR	NR
22. *Cleome gynandra* L.	220	5.68	4117	37.0	4.48	393	14.3	1.0	(Schonfeld et al., 2011); (Nesamvuni et al., 2001)
23. *Cleome monophylla* L. (*Cleome monophylla* var. *madagascariensis* Hadj-Moust)	39	5	3.98	13.2	2.14	3203	24	5	(Odhav et al., 2007)
24. *Colocasia esculenta* (L.) Schott (*Colocasia antiquorum* var. *esculenta* (L.) Schott)	NR	0.34	NR	14.3	2.50	39.10	NR	0.15	(Temesgen and Retta, 2015); (Lukman et al., 2017)
25. *Corchorus tridens* L. (*Corchorus tridens* var. *euryphyllus* Domin)	275	5.19	3663	44	2.08	530	6.3	0.8	(Chipurura et al., 2011); (Nesamvuni et al., 2001)
26. *Cucurbita pepo* L.	NR	4.10	NR	2	17.55	177	9.2	0.75	(Mashitoa and Sivakumar, 2022)
27. *Cucumis africanus* L.f.	NR	NR	NR	NR	NR	NR	NR	NR	NR
28. *Cynanchum insipidum* (E.Mey.) Liede & Khanum (*Pentarrhinum insipidum* E.Mey.)	NR	NR	NR	NR	NR	NR	NR	NR	NR
29. *Foeniculum vulgare* Mill.	NR	9.38	NR	8.7–340	18.21	56–363	9.72	2.89	(Mehra et al., 2021)
30. *Galinsoga parviflora* Cav.	NR	NR	NR	NR	NR	NR	NR	NR	NR
31. *Grewia occidentalis* L.	NR	NR	NR	NR	NR	NR	NR	NR	NR
32. *Hibiscus trionum* L.	NR	3.5	NR	2.3	0.3	240	5	NR	(Upadhyay, 2024)
33. *Ipomoea batatas* (L.) Lam.	175	2.49	2217	11	5.3	78	0.97	NR	(Alam, 2021)
34. *Ipomoea obscura* (L.) Ker Gawl. (*Convolvulus obscurus* L.)	NR	NR	NR	NR	NR	NR	NR	NR	NR
35. *Lactuca sativa* L. (*Lactuca dregeana* L.)	NR	1.2	NR	18	NR	62	2.2	0.18	(Mahlanza et al., 2023)
36. *Lagenaria siceraria* (Molina) Standl.	14	0.62	NR	NR	0.50	26	0.20	0.70	(Kunene et al., 2020)
37. *Malva parviflora* L.	NR	NR	NR	NR	NR	NR	NR	NR	NR
38. *Manihot esculenta* L.	91	1.0–10.0	0.21	60–370	0.5–10.0	34–708	0.4–8.3	71–240	(Tsige et al., 2019)
39. *Momordica balsamina* L.	53	5	NR	NR	2.75	2688	23	12	(Odhav et al., 2007)
40. *Momordica charantia* L.	NR	0.8	NR	NR	1.4	11	17.41	2.01	(Shackleton et al., 2009); (Bwembya et al., 2018)
41. *Momordica foetida* Schumach	94.0	3.30	5.41	20.6	3.15	1.06	3.38	0.42	(Nesamvuni et al., 2001)
42. *Nicandra physalodes* (L.) Gaertn.	NR	NR	NR	NR	NR	NR	NR	NR	NR
43. *Obetia tenax* (N.E. Br) Friis	NR	NR	NR	NR	NR	NR	NR	NR	NR
44. *Oxygonum dregeanum* Meisn	NR	NR	3.27	NR	NR	1636	50.86	4.86	(Phaswane, 2022)
45. *Phaseolus vulgaris* L	NR	2.2	NR	NR	1.2	80	1.8	0.2	(Shackleton et al., 2009)
46. *Portulaca oleracea* L	23	3	NR	21	1.21	1361	42	34	(Odhav et al., 2007)
47. *Portulacaria afra* Jacq	61.15	0.57	NR	NR	0.40	NR	NR	NR	(Mahlanza et al., 2023)
	NR	NR	3.52	NR	NR	3560	15.28	2.77	(Phaswane, 2022)

(*continued*)

Table 3 (*Continued*)

Scientific name	Energy KJ (kcal)	Protein (g/100 g)	Beta carotene (mg)	#Vit. C (mg/100 g)	Fibre (g/100 g)	Calcium (mg/100 g)	Iron (mg/100 g)	Zinc (mg/100 g)	Reference
48. *Pouzolzia mixta* Solms (*Pouzolzia mixta* var. *mixta*)									
49. *Rumex lanceolatus* Thunb.	92	2	NR	48	2.9	44	2.4	0.2	(Ntuli et al., 2021)
50. *Sesamum alatum* Thonn.	NR	NR	NR	NR	NR	NR	NR	NR	NR
51. *Sesamum zanguebarium* (Lour.) Byng & Christenh. (*Dicerocaryum zanguebaricum* (Lour.) Merr.)	NR	31.57	NR	NR	NR	1.88	453.0	29.0	(Ntuli et al., 2021)
52. *Solanum nigrum* L.	55	3	NR	1070	2.42	2067	85	23	(Odhav et al., 2007)
53. *Solanum retroflexum* Dunal	81.0	3.65	7.56	7.5	2.73	1.48	9.34	0.55	(Nesamvuni et al., 2001)
54. *Sonchus asper* (L.) Hill	NR	1.97	10.37	10.89	4.38	96.25	38.87	1.35	(Mokganya et al., 2021; Silva et al., 2022)
55. *Sonchus dregeanus* DC	NR	21.49	NR	NR	NR	574	1.59	46.7	(Tshikororo et al., 2023)
56. *Sonchus oleraceus* L.	NR	3.17	NR	0.058	1.11	12.25	0.56	0.14	(Bvenura and Afolayan, 2014)
57. *Spinacia oleracea* L.	26	3.2	NR	NR	4.3	736.9	26.57	5.12	(Bwembya et al., 2018); (Mariga et al., 2012)
58. *Taraxacum officinale* Weber	NR	15.48	13.8	53	47.8	695	NR	NR	(Escudero and Mediavilla, 2003)
59. *Tragia* spp.	NR	NR	NR	NR	NR	NR	NR	NR	NR
60. *Trema orientalis* (L.) Blume (*Celtis orientalis* L.)	NR	NR	NR	NR	NR	NR	NR	NR	NR
61. *Tribulus terrestris* L.	NR	10.07	NR	NR	NR	35.38		0.62	(Tshikororo et al., 2023)
62. *Tribulus zeyheri* Sond.	NR	NR	NR	NR	NR	NR	NR	NR	NR
63. *Tropaeolum majus* L.	NR	26.7	NR	NR	NR	33.72	0.64	0.90	(Kocira et al., 2018)
64. *Urtica dioica* L.	NR	28.5	NR	7	13.2	113.2	8.1	2.32	(Pradhan et al., 2015)
65. *Urtica lobulata* Blume	NR	17.29	NR	NR	NR	309.14	0.098	2.81	(Tshikororo et al., 2023)
66. *Vigna unguiculata* (L.) Walp.	189	4.07	2249	NR	48	221	3.9	0.5	(Schonfeld et al., 2011)
67. *Zantedeschia aethiopica* (L.) Spreng	NR	NR	NR	NR	NR	7.7	20.0	0.001	(Maroyi, 2019)

Table 4
Examples of biological activities and phytochemicals of locally sourced leafy vegetables in South Africa. NR – no record found.

Scientific name	Biological activities	Phytochemicals
1. *Abelmoschus esculentus* Moench	Antioxidant, anti-inflammatory, immunomodulatory, antibacterial, anticancer, antidiabetic, neuropharmacological (Islam, 2019)	Saponins, tannins, phlobatannins, flavonoids, alkaloids, steroids, glycosides, anthraqinones, phenol, terpenoids (Sani and Abdulhamid, 2016)
2. *Adenia digitata* (Harv.) Engl.	Antioxidant, anti-inflammatory (Lall and Kishore, 2014)	NR
3. *Amaranthus blitum* L (*Amaranthus blitum* subsp. *oleraceus* (L). Costea)	Antibacterial (Nehal et al., 2016)	Alkaloids, glycosides, flavonoids, phenol, terpenoids, saponins (Joy et al., 2020)
4. *Amaranthus blitoides* S. Watson	NR	NR
5. *Amaranthus dubius* Mart ex thela	Antioxidant, immunomodulatory (Zhang, 2017)	NR
6. *Amaranthus cruentus* L. (*Amaranthus esculentus* Besser)	Antioxidant, immunomodulatory, hepatoprotective (Gandhi et al., 2021)	Polyphenols, tannins, flavonoids, steroids, terpenoids, saponins, betalains (Nana et al., 2012)
7. *Amaranthus hybridus* L.	Antioxidant, antiproliferative, antimicrobial (Al-Mamun et al., 2016)	Alkaloid, flavonoid, saponin, tannin, phenols, hydrocyanic acid, phytic acid (Akubugwo et al., 2008)
8. *Amaranthus spinosus* L.	Antidiabetic, anti-inflammatory, immunomodulatory (Amabye and Said, 2015)	Alkaloids, saponins, flavonoids, polyphenols, tannins (Sharma et al., 2021)
9. *Amaranthus thunbergii* Moq.	Antioxidant (Bang et al., 2021)	Phenolics (Walt et al., 2009)
10. *Amaranthus* L	Antioxidant (Bang et al., 2021)	NR
11. *Beta vulgaris* L.	Antioxidant, antimicrobial, anti-inflammatory, antiproliferative, antiviral (Rehman et al., 2023)	Flavonoids, tannins, oxalate, anthocyanins, saponins, phenolics, phytate (Singh et al., 2015)
12. *Bidens pilosa* L. (*Bidens pilosa* var. *leucantha* (L.) Harvey)	NR	NR
13. *Brassica oleracea* L.	Antioxidant, anti-genotoxic (Koss-Mikołajczyk et al., 2019)	Alkaloids, steroids, tannins, phenols, flavonoids, glycosides, saponins, terpenes (Paul et al., 2019)
14. *Brassica rapa* L.	Antimicrobial, antioxidant (Beltagy, 2014)	Lucosinolates, isothiocyanates, flavonoids, volatiles (Paul et al., 2019)
15. *Brassica* spp.	Anti-cancer, anti-inflammatory (Shin et al., 2014)	Terpenoid, alkaloids, phenolics, steroid, curcumines, saponins, flavonoids, glucosides (Favela-González et al., 2020)
16. *Bryonia alba* L.	Antioxidant (Ielciu et al., 2019)	Flavonoids, saponins, terpenoids, anthocyanins, coumarins, alkaloids, polyphenols, tannins, emodins (Katiyar et al., 2023)
17. *Catha edulis* (Vahl) Forssk. ex Endl. (*Catha edulis* (Vahl.) Endl.)	Antimicrobial (Mohamed Abdoul-Latif et al., 2023)	NR
18. *Centella coriacea* Nannf.	NR NR	NR

(*continued*)

Table 4 (*Continued*)

Scientific name	Biological activities	Phytochemicals
19. *Chenopodium album* L (*Chenopodium album* var. *viride* (L.) Pursh)		Phenols, alkaloids, flavonoids, glycosides, saponins (Rathna Priya et al., 2019)
20. *Chenopodium murale* L.	Antifungal, antibacterial (Ahmad et al., 2012)	Phenols, flavonoid, tannins, saponins, steroids, terpenoids, phlobatannins, coumarins, cardiac glycoside, anthraquinones (Khan et al., 2019)
21. *Citrullus lanatus* (Thunb.) Matsum. & Nakai	Antimicrobial (Masoko et al., 2022)	Phenolic, flavonoid, tannin (Masoko et al., 2022)
22. *Cleome gynandra* L.	Antimicrobial (Hamill et al., 2003)	Protocatechuic acid, hydroxybenzoic acid, salicylic acid, caffeic acid, coumaric acid, sinapic acid, ferulic acid (Moyo and Aremu, 2022)
23. *Cleome monophylla* L. (*Cleome monophylla* var. *madagascariensis* Hadj-Moust)	NR	NR
24. *Colocasia esculenta* (L.) Schott (*Colocasia antiquorum* var. *esculenta* (L.) Schott)	NR	Alkaloids, glycosides, flavonoids, terpenoids, saponins, oxalates, phenols (Khasanah et al., 2022)
25. *Corchorus tridens* L.	NR	Phenolics, flavonoids, cardiac glycosides, sterols, coumarins, tannins, terpenoids, alkaloids (Kudumela et al., 2024)
26. *Cucurbita pepo* L.	Antioxidant, anti-obesity (Zhang, 2017)	NR
27. *Cucumis africanus* L.f.	Antioxidant (Abifarin et al., 2019)	Phenolics, proanthocyanidins, flavonoids, alkaloid, saponin (Abifarin et al., 2019)
28. *Cynanchum insipidum* (E.Mey.) Liede & Khanum (*Pentarrhinum insipidum* E.Mey.)	NR	Steroids, steroidal saponins, alkaloids, flavonoids, terpenes (Han et al., 2018)
29. *Foeniculum vulgare* Mill.	Antioxidant, antitumor, chemopreventive, cytoprotective, hepatoprotective, hypoglycemic, oestrogenic (Malini et al., 1985)	Phenols, phenolic glycosides (Rather et al., 2016)
30. *Galinsoga parviflora* Cav.	Antibacterial, antioxidant, diabetic, antifungal (Ripanda et al., 2023)	Triacontanol, phytol, β-sitosterol, stigmasterol, 7-hydroxy-β-sitosterol, 7-hydroxystigmasterol, β-sitosterol-3-O-β-D-glucoside, 3,4-dimethoxycinnamic acid, protocatechuic acid, fumaric acid, uracil (Islam et al., 2013)
31. *Grewia occidentalis* L.	Analgesic, anticancer (cytotoxicity), antidiabetic, antiemetic, anti-inflammatory (Kumar et al., 2022)	Flavonoids, tannins, amino acids, anthocyanins (Swain et al., 2023)
32. *Hibiscus trionum* L.	Antihypertensive, antiatherosclerotic, antioxidant, antihypercholesterolaemic, antinociceptive, antipyretic, antimutagenic, antifungal, antibacterial (Kılıç et al., 2011)	Phytosterols, saponins (Kapoor et al., 2021)
33. *Ipomoea batatas* (L.) Lam.	NR	Phenolics, anthocyanins, tannins (Amagloh et al., 2022)
34. *Ipomoea obscura* (L.) Ker Gawl. (*Convolvulus obscurus* L.)	Antioxidant, anti-inflammatory (Rathod and Mathad, 2018)	Alkaloids, coumarins, flavonoids, phenolics (Mungole et al., 2010)
35. *Lactuca sativa* L. (*Lactuca dregeana* L.)	Antibacterial (Silva et al., 2022)	NR
36. *Lagenaria siceraria* (Molina) Standl.	NR	NR
37. *Malva parviflora* L.	NR	Tannins, alkaloids, saponins, flavonoids, phenols (Ahmed et al., 2018)
38. *Manihot esculenta* L.	Antibacterial, ovicidal, larvicidal, antioxidant, anti-inflammatory, analgesic, antipyretic (Scaria et al., 2023)	Flavonoids, tannins, stilbenes, saponins (Mohidin et al., 2023)
39. *Momordica balsamina* L.	NR	Flavonoids, naphthoquinones, coumarins, terpenoids, sterols, phenols (Qian et al., 2023)
40. *Momordica charantia* L.	Antidiabetic, anti-cancer, antidepressant (Joseph and Jini, 2013)	Flavonoid, alkaloid, saponin, triterpenoidal steroids, glycoside, tannin (Sani and Abdulhamid, 2016)
41. *Momordica foetida* Schumach	Antioxidant (Acquaviva et al., 2013)	Alkaloids, glycosides steroids, saponins, phenolics, terpenes, flavonoids (Khasanah et al., 2022)
42. *Nicandra physalodes* (L.) Gaertn.	Antibacterial, antifungal (Gupta et al., 2014)	NR
43. *Obetia tenax* (N.E. Br) Friis	Antioxidant, antidiabetic (Mahlangeni et al., 2020)	NR
44. *Oxygonum dregeanum* Meisn	Anti-plasmodial (Nafuka, 2014)	Alkaloids, tannins, flavonoids, saponins, steroids, glycosides, terpenoids (Phaswane, 2022)
45. *Phaseolus vulgaris* L	NR	Alkaloids, anthocyanins, catechins, flavonoids, phytic acid, quercetin, saponins, steroids, tannins, terpenoids, trypsin (Khasanah et al., 2022)
46. *Portulaca oleracea* L	Antibacterial (Lei et al., 2015)	Terpenes, triterpenoids, phenolics, alkaloids (Petropoulos et al., 2016)
47. *Portulacaria afra* Jacq	Antimicrobial, antioxidant (Adeleye and Risenga, 2022)	Flavonoids, phenolics (Tabassum et al., 2022)
48. *Pouzolzia mixta* Solms (*Pouzolzia mixta* var. *mixta*)	NR	Alkaloids, steroids, tannins, glycosides, saponins, terpenoids (Phaswane, 2022)
49. *Rumex lanceolatus* Thunb.	Antibacterial, antimalarial, anti-inflammatory, antioxidant (Maroyi, 2019)	Anthraquinones, naphthalenes, flavonoids, stilbenoids, tannins, triterpenoids, carotenoids (Vasas et al., 2015)
50. *Sesamum alatum* Thonn.	Antioxidant, antiglycation (Bedigian, 2018)	NR
51. *Sesamum zanguebarium* (Lour.) Byng & Christenh. (*Dicerocaryum zanguebaricum* (Lour.) Merr.)	NR	NR
52. *Solanum nigrum* L.	Antimicrobial, antifungal (Ahmad and Habib, 2014)	Alkaloid, flavonoids, saponins, tannin, phenols, hydrocyanic acid, phytic acid (Akubugwo et al., 2008)
53. *Solanum retroflexum* Dunal	Antioxidant (Khan et al., 2019)	Steroids, terpenes, saponins, tannins, flavonoids (Daji et al., 2018)

(*continued*)

Table 4 (*Continued*)

Scientific name	Biological activities	Phytochemicals
54. *Sonchus asper* (L.) Hill	Antioxidant, antimicrobial (Ahmad and Habib, 2014)	Flavonoids, terpenoids, fatty acids (Sani and Abdulhamid, 2016)
55. *Sonchus dregeanus* DC	Anti-microbial, anti-inflammatory (Moteetee and Kose, 2017)	NR
56. *Sonchus oleraceus* L.	Antioxidant, antidiabetic, anxiolytic (Puri, 2018)	Flavonoids, apigenin, quercetin (Alrekabi and Hamad, 2018)
57. *Spinacia oleracea* L.	Antioxidant, anti-inflammatory (Metha and Belemkar, 2014)	Tannins, flavonoids, glycosides, steroids, terpenoids, lignin (Rao et al., 2015)
58. *Taraxacum officinale* Weber	Antioxidant, anti-inflammatory (González-Castejón et al., 2012)	Phenols, flavonoids (Murtaza et al., 2022)
59. *Tragia* spp.	NR	Alkaloid, glycoside, tannin, flavonoid, sterols, saponin (Reddy et al., 2017)
60. *Trema orientalis* (L.) Blume (*Celtis orientalis* L.)	Antimicrobial (Zhang, 2017)	Tannins, saponins, flavanoids, n-hexadecanoic acid, farnesylacetone, triterpenoid (simiarenol, simiarenone, trematol) (Parvez et al., 2019)
61. *Tribulus terrestris* L.	NR	Saponins, flavonoids, glycosides, alkaloids, tannins (Chhatre et al., 2014)
62. *Tribulus zeyheri* Sond.	NR	NR
63. *Tropaeolum majus* L.	NR	Alkaloids, tannins, anthraquinone, glycosides, saponins, flavonoids, phlobatanins, steroids, terpenoids, cardiac glycoside, coumarin, emodins, betacyanin (Schonfeld et al., 2011)
64. *Urtica dioica* L.	Antibacterial, antioxidant, analgesic, anti-inflammatory, antiviral, immunomodulatory, anticancer (Joshi et al., 2014)	Phenolic acids, phenolics, flavonoids, steroids, triterpenoids, carotenoids (Sani and Abdulhamid, 2016)
65. *Urtica lobulata* Blume	Antibacterial (Maroyi, 2019)	Alkaloids, tannins, saponins steroids, phlobatannin, terpenoids, flavonoid, cardiac glycosides (Fagbohun and Lawal, 2011)
66. *Vigna unguiculata* (L.) Walp.	Anti-obesity (Olaoluwa et al., 2022)	Gentisic acid, 5-O-glucoside, disaccharide, coumaric acid-O-glucoside, citrusin C, myricetin-O-pentoside, alkaloid, flavonoids (Pioltelli et al., 2023)
67. *Zantedeschia aethiopica* (L.) Spreng	Antibacterial, antifungal, antithrombotic, anticoagulant (Maroyi, 2019)	Galactolipids, galactosyldiacylglycerols α-linoleic acid 13-hydroxy-α-linolenic acid, linoleic 9-hydroxy-linoleic acid, 12-hydroxy-linoleic acid, myristic acid (Maroyi, 2019)

cultivated (1.4 %, 1 plant species) plants were relatively low. Efforts and initiatives have been undertaken to promote the cultivation and consumption of underutilized leafy vegetables, driven by concerns for food security, biodiversity conservation, and improved nutrition. These vegetables exhibit climate resilience, thriving in harsh conditions, which can contribute to food and nutrition security by providing a reliable source of nutritious food. Initiatives are continously underway to raise awareness about leafy vegetables, thereby combating the stigma associated with them through improved varieties, market channels, and food-nutrition education (Jansen van Rensburg et al., 2014). Incorporating these leafy vegetables into dietary interventions or public health programs contribute toward addressing malnutrition, promoting sustainable food systems, preserving agricultural biodiversity, and increasing access to locally available nutrient-rich foods. For example, regular consumption of leafy vegetables has been linked to reduced risks of chronic conditions such as diabetes, cancer, and cardiovascular diseases, which has been attributed to their bioactive components (Muraki et al., 2013). Diversifying diets and promoting leafy vegetables can enhance food and nutrition security especially for the vulnerable populations, offering an affordable and nutrient-dense alternative(s). Therefore, cultivating leafy vegetables especially the underutilised ones supports sustainable agriculture practices, reducing pressure on other crops and contributing to ecosystem balance. Additionally, leafy vegetables can generate income for local farmers, particularly women and uplift the economy and purchasing power of rural communities (Imathiu, 2021).

3.7. Research limitation and gaps for future studies on leafy vegetables

This review highlights the need for further research on leafy vegetables used for food, nutrition, and health benefits in South Africa. Currently, many ethnobotanical surveys lack detailed information on the specific conditions these plants are used for, the method of preparation, and which parts of the plant are used. This lack of comprehensive information highlights the importance of conducting well-planned and holistic ethnobotanical surveys in the future. Furthermore, it would be advantageous to utilize indigenous research methodologies when exploring the use of leafy vegetables. This approach would provide a deeper understanding of the cultural significance of these plants as perceived by the participants. The review further identified the necessity for biological and phytochemical studies to complement existing data on the indigenous knowledge of locally sourced leafy vegetables in South Africa. The cultivation protocols, adaptability, and active compounds of underutilized leafy vegetables are also pertinent, as such data could lead to novel health supplements or medicines.

4. Conclusion and recommendations

The findings of this review highlight the continued consumption of leafy vegetables by rural households, and has provided valuable insights into their ethnobotanical, biological, and phytochemical qualities. These leafy vegetables play a crucial role in enhancing the food- nutritional status and overall well-being of the population. A total of 67 leafy vegetables from 23 different families were identified with Amaranthaceae (12 plant species), Asteraceae (7 plant species), Cucurbitaceae (8 plant species), Malvaceae (5 plant species) and Urticaceae (4 plant species), emerging as the top-ranked families. A total of 16 out of 67 plants were the identified as the most popular with 3–7 citations. These were *Bidens pilosa* (8), *Vigna unguiculata* (6), *Amaranthus hybridus* (6), *Cleome gynandra* (5), *Abelmoschus esculentus* (3), *Amaranthus dubius* (3), *Amaranthus spinosus* (3), *Citrullus lanatus* (3), *Centella coriacea* (3), *Chenopodium album* (5), *Colocasia esculenta* (3), *Ipomoea batatas* (3), *Momordica balsamina* (3), *Solanum* *retroflexum* (3), *Sonchus asper* (3) and *Spinacia oleracea* (3). From an ethnobotanical perspective, leafy vegetables have a long history of traditional use, with local communities relying on them for their nutrition and medicinal properties. This knowledge has been passed down through generations, highlighting the cultural significance of these vegetables. However, the limited awareness and indigenous knowledge about their nutritional value and preparation methods, as well as the perception that they are inferior to exotic vegetables, hinder their consumption on a large scale. They have been found to possess a wide range of health benefits as they are rich in essential nutrients such as vitamins, minerals, and dietary fiber. Regular consumption of these leafy vegetables has been associated with reduced risk of chronic diseases, including cardiovascular diseases, diabetes, and certain types of cancer. The phytochemicals in these recorded leafy vegetables are known to exert diverse biological effects, such as antioxidant, anti-inflammatory, and antimicrobial properties. Based on the potential associated with these leafy vegetables, integrating their existing traditional knowledge with scientific research on the ethnobotanical, biological, and phytochemical qualities can lead to a more comprehensive understanding of their potential health benefits. This approach can inform policies and interventions aimed at improving the utilization of leafy vegetable for attaining the acceptable nutritional level, good health, and general well-being in rural areas where they often occur naturally. Additionally, there is a need for further research and awareness of these locally available leafy vegetables to fully understand their potential nutritional value, health benefits and optimize their cultivation and preservation techniques.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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