



Local Knowledge, Perceptions, and Uses of the Potentially Conflict-Generating Plant Species, *Moringa oleifera* Lam.: A case Study in Limpopo Province, South Africa

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Abstract

Moringa oleifera Lam. is listed In South Africa as Species Under Surveillance for Possible Eradication or Containment Targets (SUSPECT) under the National Environmental Management: Biodiversity Act 10 of 2004 (NEM:BA), although it is widely used in some communities. We conducted this study to investigate local ecological knowledge (LEK) and perceptions about moringa in the rural communities of Limpopo Province (South Africa). We used a structured questionnaire and open-ended interviews with 106 informants to gather ethnobotanical data associated with utilisation and perceptions of moringa. We found that moringa is generally perceived positively and is used primarily for medicinal purposes, its nutrition value, as livestock feed, and for skin care. Most participants (76%) were unaware that moringa is an alien species and disagreed with NEM:BA regulations to restrict its spread or to eradicate it entirely due to the benefits they associate with it. We argue that listing moringa as SUSPECT could fuel conflict between rural communities that use it and management authorities. Rather, we would urge policymakers to adopt a holistic approach to sustainable conservation strategies that incorporates LEK in future planning.

Keywords Local Ecological Knowledge · Rural Communities · Moringa · Medicinal Uses · Nutrition · Commercial Potential · SUSPECT · Limpopo Province · South Africa

Introduction

Due to its numerous uses including nutritional and medicinal benefits, *Moringa oleifera* Lam. (hereafter moringa) has been described a super food species (Ekesa, 2017). Moringa is native to sub-Himalayan parts of northern India and is widely distributed across tropical and sub-tropical regions of the world (Arun & Sarita, 2011). Nutritionally, almost all its parts (above- and below-ground biomass) are considered rich sources of vitamins, proteins, and minerals (Fahey, 2005; Brilhante et al., 2017). It is well-recognized that moringa is used as traditional medicine for more than 100 health-related conditions (Anwar et al., 2007; Bancessi et al., 2020; Ma et al., 2020). Moringa seeds are used to purify water, and their oil is used in the production of biodiesel fuel and cosmetics (Saini et al., 2016). Currently, there is growing interest from governments and organisations in developing countries in the use of moringa to alleviate poverty and malnutrition in marginalized communities (Ma et al., 2020).

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Following the introduction of moringa as a cultivated crop to rural communities of Limpopo Province (South Africa) in 2006 several NGOs as well as farmers and government departments undertook projects with the primary objective of promoting the use, production, and commercialisation of moringa through collaborations, research, community training, farming, industrial product development, and marketing (<https://www.mdasa.org/>) (Lekgau, 2011; Mabapa et al., 2017). The Moringa Development Association of South Africa (MDASA) was established in 2013 to address socio-economic development issues such as nutrition, medicine, job creation, and enterprise. By 2017 the presence of moringa farmers was reported in all five district municipalities of Limpopo Province (i.e., Capricorn, Mopani, Sekhukhune, Vhembe, and Waterberg) and most had intentions of commercialising the plant (Mabapa et al., 2017).

The pharmacological properties of moringa led to its listing on the profile of South African medicinal plants (DAFF, 2016). The South African Department of Science and Technology (DST) (now known as DSI: Department of Science and Innovation) gave moringa flagship status in 2010 to encourage the interface of science and Indigenous Knowledge Systems (IKS). Indigenous Knowledge Systems funding of the DSI and National Research Foundation (NRF) is promoting and supporting research that focuses on IKS, community development and involvement (NRF, 2018). In 2016, DSI successfully launched a moringa farm along with agro-processing facilities and continues to fund other moringa-related projects (DST, 2016).

Nonetheless, moringa is listed on South Africa's Species Under Surveillance for Possible Eradication or Containment Targets (SUSPECT) under the National Environmental Management: Biodiversity Act (NEM:BA), which permits assessment of its invasive potential posing threats to indigenous flora (van Wilgen and Wilson, 2018). It is possible that considerations of its invasive potential may prove contentious in light of its numerous potential societal benefits and could hamper the attainment of the Sustainable Development Goals (SDG 1–3) of No Poverty, Zero Hunger, as well as Good Health and Well-being (United Nations, 2020). Such plants are known as conflict-generating species because they can simultaneously have high positive and negative impacts on ecosystem services (van Wilgen and Richardson, 2014; Novoa et al., 2016; Ngorima and Shackleton, 2019), and communities tend to be disinclined to accept control measures for species with perceived socio-cultural, economic, and ecological importance.

Even though moringa is fast becoming a cultivated crop in South Africa (Mabapa et al., 2017; Tshabalala et al., 2020; Mashamaite et al., 2021), perceptions about, and uses of, this plant are relatively undocumented. Discussion of conflicts surrounding alien invasive species and societal benefits

is largely lacking in environmental management studies in South Africa (Shackleton et al., 2016). Conflict-generating species need a neutral evaluation of their costs and benefits. Furthermore, policymakers should incorporate indigenous knowledge and perceptions into in planning management strategies (Zengeya et al., 2017). Indeed, IKS could be used to resolve such conflicts since local communities are directly involved with the daily necessities of utilisation and management of local environments (Ngorima & Shackleton, 2019). Therefore, the aim of this study was to assess the local knowledge and perceptions about moringa among individuals living in areas of its established populations.

Materials and Methods

Description of the Study Site

We conducted this study between February and March 2019 in all five district municipalities of Limpopo Province: namely, Capricorn, Mopani, Sekhukhune, Vhembe, and Waterberg. We randomly selected four villages (at least 20 km from each other) for each district and recruited at least five individual participants in each village (Fig. 1).

Limpopo (23.4013°S, 29.4179°E), one of South Africa's nine provinces, is bordered by Botswana, Mozambique, and Zimbabwe. The population of Limpopo Province was estimated at 5.9 million, making it the fifth-largest province in the country by population size (Stats SA, 2020). Poverty in Limpopo Province has increased from approximately 10.0% in 2011 to about 11.5% in 2016 (Stats SA, 2019). Increases in the poverty headcount were observed in all district municipalities between these years, except in Vhembe where there was a slight decrease from 13.0% to 2011 to 12.8% in 2016 (Stats SA, 2019).

Participants and Data Collection

We used a mixed-methods approach with a questionnaire to explore individual familiarity with moringa duration, uses, utilisation, and government legislation concerning alien species, followed by interviews to explore in-depth uses and perceptions about moringa (Creswell, 2014). We used purposive sampling based on the selection of samples that contained the most relevant characteristics or typical attributes of the population under investigation (Flick, 2008). Our inclusion criteria for participation were that individuals had to have moringa trees on their farms, or in their gardens or backyards.

We administered surveys and conducted follow-up interviews with 106 participants aged 18 or older. Participants included 24 individuals (22.6%) from Capricorn, 22 (20.8%)

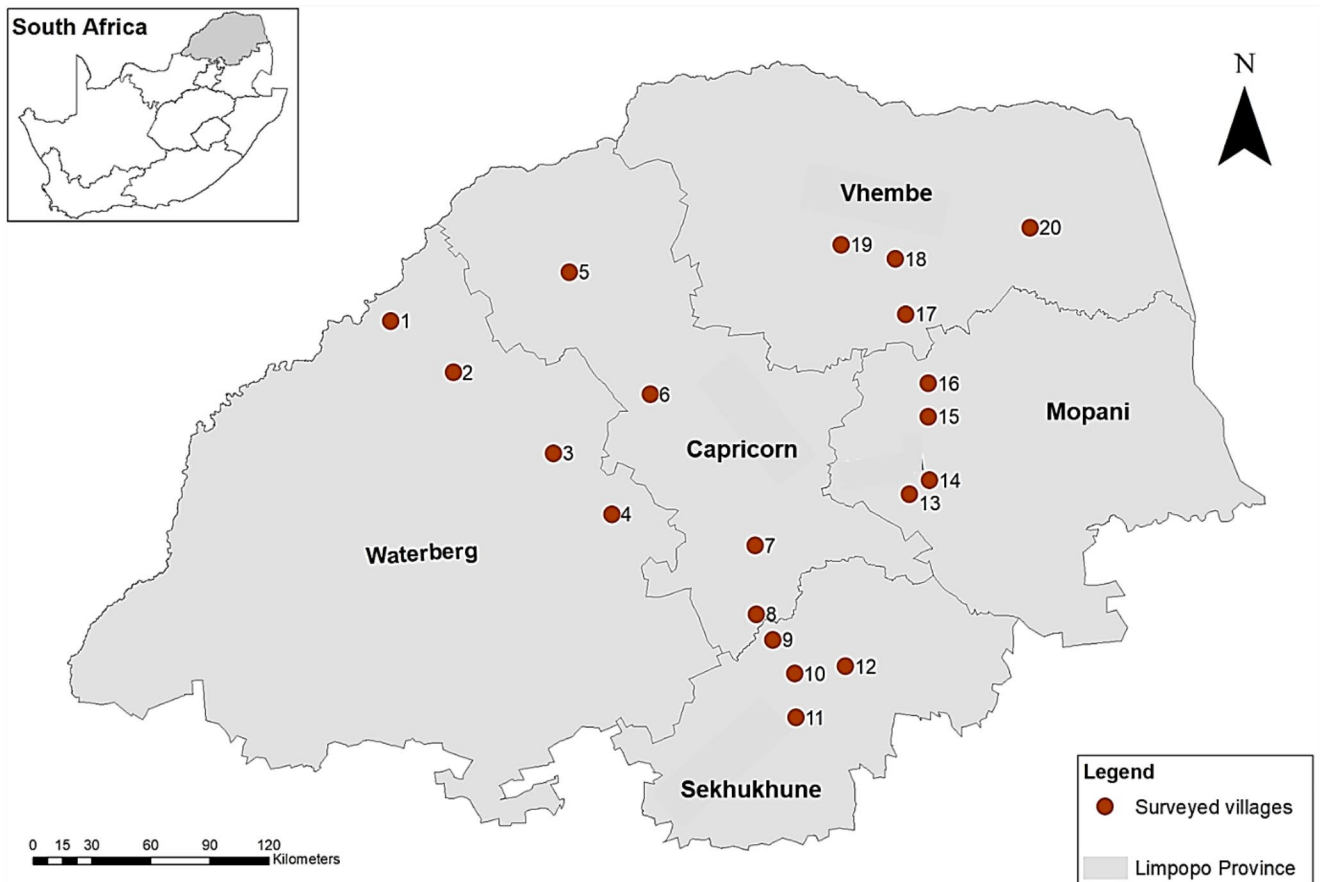


Fig. 1 Map of Limpopo Province showing districts and locations of sampled villages. The villages are represented by red dots and numbers; 1 = Ga-Seleka, 2 = Ga-Maeteletsa, 3 = Ga-Molekwa, 4 = Ga-Mapela, 5 = Letshwatla, 6 = Ga-Mabitsela, 7 = Ga-Maja, 8 = Tooseng,

9 = Ga-Masemola, 10 = Ga-Phaahla, 11 = Phokwane, 12 = Manganeng, 13 = Ga-Maake, 14 = Litsitele, 15 = Ga-Modjadji, 16 = Koope, 17 = Hlanganani, 18 = Tshitavha, 19 = Tshikuwi, 20 = Tshikundu

from Mopani, and 20 (18.9%) each from Sekhukhune, Vhembe, and Waterberg. The questionnaire comprised three key sections soliciting information on (1) participant demographics; (2) familiarity, uses, and perceptions of moringa; and (3) knowledge on government biodiversity legislation (see supplementary material A). Some of the responses in the questionnaire were based on a Likert scale (i.e., 1 = very satisfied to 5 = very dissatisfied). To explore IKS and subjective meanings attached to the uses of moringa, as well as participants' lived experiences of cultivating moringa, we conducted semi-structured interviews (see supplementary material B). Qualitative questions included: (i) what do you use moringa for? (ii) what are the perceived benefits of using moringa? and (iii) how do you process, store, and prepare your moringa? Translators were employed when required because the Limpopo Province is multicultural and multilingual with differing proficiencies in the main languages, which include Sepedi, Tshivenda, Xitsonga, and English.

Ethical Considerations

We complied with Stellenbosch University's policy on research ethics and permission was received from the University's Research Ethics Committee (REC: 2018–7868) prior to data collection to ensure that the research was ethically conducted. Stellenbosch University policies, appropriate legal framework and ethical considerations were adhered to during and beyond completion of this study. We ensured that the dignity, rights, safety, and well-being of all participants were protected. Each participant was assured of anonymity and confidentiality. We emphasized the voluntary nature of their participation and their ability to withdraw from the study without consequences. We assigned each participant an identity code using the first letter of the district name and numbers assigned to participants (e.g., C.01 = Capricorn district participant 1; M.19 = Mopani district participant 19; W.07 = Waterberg district participant 7).

Each participant was asked to sign a consent form in a language they were proficient in (see supplementary material

C). Participants' responses were translated into English during the transcription process and were checked by a translator as well as study supervisors to verify the accuracy of the translation. Transcribed interviews were stored on an encrypted and password-protected, encoded external hard drive. The transcribed interviews were accessible only to the author and supervisors. Non-identifying data were also stored at Stellenbosch University's repository in line with internal data management plan (<https://library.sun.ac.za/en-za/Research/rdm/Pages/rdm-su.aspx>), compliant with Protection of Personal Information (POPI) Act No. 4 of 2013 (Information Regulator South Africa, 2013).

Data Analysis

We analysed quantitative data using the Statistical Package for Social Science (IBM SPSS Statistics v. 26) and used descriptive statistics to generate frequencies and percentages of the responses. Pearson's Chi-square test of association (χ^2) was conducted to predict the likelihood of participants' moringa use by giving proportion at the probability of 5%. For the qualitative strand, we used a general inductive approach that involved detailed readings of raw interview data to derive specific themes (Thomas, 2006) to facilitate Braun and Clarke's (2006) six-step thematic analysis. Transcribed interviews were read several times to identify themes and sub-themes that captured core messages reported by participants following Miles and Huberman (1993). Transcripts were also read horizontally, which involved grouping segments of text by theme. Towards the end of the transcripts, no new themes emerged, which suggested that major themes had been identified and data saturation had been reached (Thomas, 2006). The themes and sub-themes were supported by verbatim examples taken from the transcribed text. Inter-reliability was guaranteed with the supervisors involved in the thematic analysis. Independent coding was compared to assess whether the resulting themes corresponded with those found by the primary researcher as a quality check.

Results and Discussion

Demographic Profiles Data

The age range of participants was grouped into six categories (i.e., 18–20; 21–30; 31–40; 41–50; 51–60; and above 60). Most of the participants were above 60 years of age (26%), with only 5% aged below 20 years. There were more female (63%) than male (37%) participants. Many of the respondents had completed secondary education, while only

Table 1 Socio-demographic profile of participants (Total sample N= 106, and N= 106 presented by category)

Variable	Response	Frequency	Proportion of participants (%)
Age	18–20	5	5
	21–30	18	17
	31–40	19	18
	41–50	14	13
	51–60	22	21
	Above 60	28	26
Gender	Male	39	37
	Female	67	63
Education level	None	18	17
	Primary	23	22
	Secondary	48	45
	Tertiary	17	16

Table 2 Awareness and familiarity of moringa by rural communities of Limpopo Province (Total sample N= 106, and N= 106 presented by category)

Variable	Response	Frequency	Proportion of respondents (%)
Hearing of moringa	Extension officer	12	11
	Internet	4	4
	Family/community member	64	60
	TV/Radio	21	20
	Other	5	5
Duration of knowing about moringa	less than 1 year	5	5
	1–3 years	33	31
	4–6 years	30	28
	7–9 years	21	20
	10 years and above	17	16

a few had either no education (17%) or attained tertiary education (16%) (Table 1).

Local Communities' Awareness of Moringa

Most participants heard about moringa from their family/community members (60%), while only a few (4%) indicated that they read about moringa from the internet (Table 2). These results reflect those of Neergheen-Bhujun et al. (2020), who reported that family members were the primary source of information about moringa in Mauritius (see also Farinola et al., 2014). However, Ikwuakam et al. (2013) reported that rural dwellers in Katsina State, Nigeria, identified the media (mainly radio) as the common sources of information about moringa (see also Seifu and Teketay, 2020 for Botswana).

We divided the length of time respondents reported they had known about moringa into five categories (Table 2).

Nearly a third had known about moringa for between 1 and 3 years and a further 28% for 4–6 years. Our results indicate an increase in awareness of moringa in Limpopo Province over the last 10 years, accompanied by a similar increase in the importance attached to its uses and values (cf. Torimiro et al., 2009).

Local Communities' Uses of Moringa

All participants (106) confirmed that they used moringa in various aspects of their livelihood activities: 34% for medicinal purposes, 25% for nutrition, 31% for both medicine and nutrition, and the remaining 10% for shade (see Fuglie, 2001) (Table 3). The prevalent use of moringa for medicinal properties or mixed in food is in accordance with findings by other studies (e.g., Kola-Oladiji et al., 2014; Popoola and Obembe, 2013; Oyewole et al., 2014).

Most participants reported using moringa on a daily and weekly basis (37% each, a total of 74%). Others used it less frequently and/or monthly (13% each, a total of 26%). These results reflect the findings of Oyewole et al. (2014), who documented that most rural and urban dwellers in Nigeria use moringa on a daily and weekly basis, while few used it monthly and seldom. Our results indicate that moringa leaves are the most utilised part of the plant (61%), while roots are used the least (6%) (see Popoola and Obembe, 2013 for Nigeria). However, participants indicated that all parts of the plant are (i.e., leaves, bark, flowers, pods, seeds, and roots) used as reported by e.g., Farooq et al. (2012) and Gupta et al. (2018).

Close to 75% of participants reported that they mix moringa leaves with their daily foods (Table 3) (Seifu & Teke-tay, 2020). Zungu et al. (2020) report that the inclusion of moringa in daily diets can improve nutrition among vulnerable communities in developing countries. In terms of moringa availability, most respondents (85%) confirmed that leaves and seeds are available throughout the year, although a few (15%) argued that they had encountered shortages during winter possibly due to freezing and very low temperatures (Batool et al., 2020). The fact that the majority

Table 3 Local knowledge and perception of moringa by rural communities of Limpopo Province (Total sample N=106, and N=106 presented by category)

Variable	Response	Frequency	Proportion of respondents (%)
Purpose of use	Medicine	36	34
	Nutrition	26	25
	medicine and nutrition	33	31
	Shade	11	10
Moringa use interval	Daily	39	37
	Weekly	39	37
	Monthly	14	13
	Occasionally	14	13
Utilised moringa part	Leaves	65	61
	Seeds	13	12
	Roots	6	6
	All parts	22	21
Mixing with foods	Yes	78	74
	No	28	26
Moringa availability	available in all seasons	90	85
	Shortage in winter	16	15
Moringa recommendations	Yes	89	84
	No	17	16

of our participants confirmed the availability of the leaves and seeds all year round may be due to the warm weather of the region (Daron, 2014). Both Pahla et al. (2013) and Kou et al. (2018) have reported the availability of all moringa plant parts throughout the year, and that the trees are able to survive in all seasons in tropical and subtropical regions due to their drought tolerance and fast growth habits as well as their long tuberous tap roots that grow very deep into the soil absorbing water and mineral salts from sub-soils (Mohammed, 2015).

Our results did not indicate any differences in use or usage of moringa according to age ($p > 0.05$) or gender, with the strength of association being weak (Table 4). The majority of moringa uses were associated with women, even

Table 4 Familiarity, local knowledge, and perceptions of moringa by age and gender (Total N = 106)

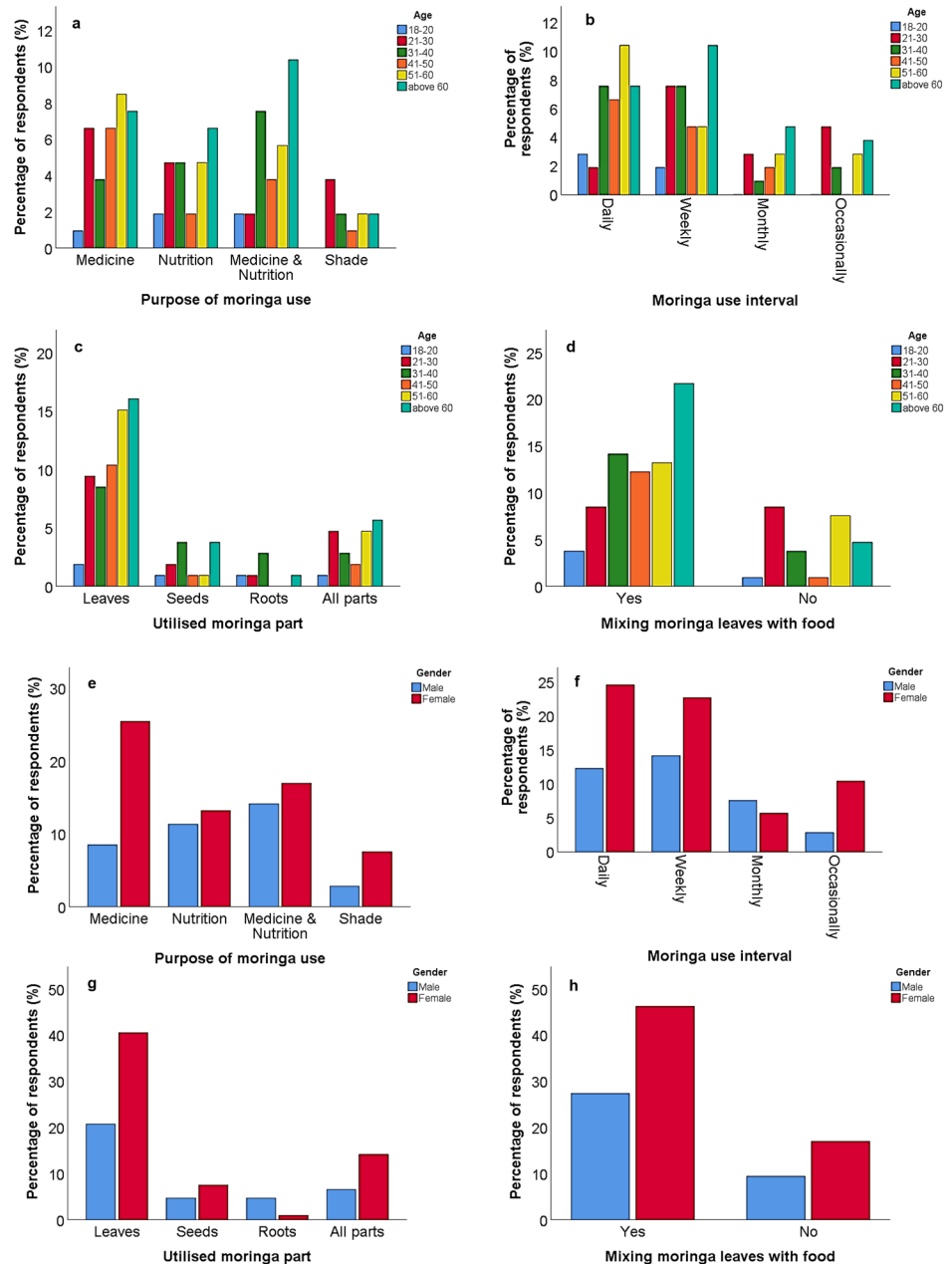
Variables		χ^2	DF	P	Phi/ Cramer's V
Age	Moringa use	8.403	20	0.080	Phi = 0.28; V = 0.28
	Purpose of using moringa	11.504	15	0.716	Phi = 0.32; V = 0.19
	Moringa use interval	15.745	15	0.399	Phi = 0.39; V = 0.22
	Utilised moringa part	13.639	15	0.553	Phi = 0.36; V = 0.21
	Mixing moringa with food	10.388	5	0.065	Phi = 0.31; V = 0.31
Gender	Moringa use	1.108	1	0.293	Phi = 0.10; V = 0.10
	Purpose of using moringa	4.626	3	0.201	Phi = 0.21; V = 0.21
	Moringa use interval	4.162	3	0.108	Phi = 0.20; V = 0.20
	Utilised moringa part	6.081	3	0.108	Phi = 0.24; V = 0.24
	Mixing moringa with food	0.019	1	0.890	Phi = 0.01; V = 0.01

though this was not statistically significant (cf. Neergheen-Bhujun et al., 2020).

Many participants above 60 years used moringa mainly for medicinal and nutritional purposes (Fig. 2a). Moringa was used more on daily basis by those aged between 51 and 60 years, whereas those who used it weekly and monthly were above 60 years (Fig. 2b). The highest percentage of participants using leaves only, seeds only, and all parts of moringa were above 60 years (Fig. 2c). Compared to other age ranges, most participants above the age of 60 years mixed moringa in foods (Fig. 2d) (cf. Popoola and Obembe 2013). In addition, older participants viewed moringa as a valuable tree with multiple benefits such as medicine,

food, and fodder as well as a coagulant for purifying water. Vitalini et al. (2013) concluded that knowledge on the uses of plant species is primarily reserved by elders who had learned it from their forefathers. With respect to gender, we found that females used moringa for a wider variety of purposes and more frequently (daily and weekly) than males (monthly) (Fig. 2e and f). The uses of all moringa parts, as well as mixing it in foods, were more common among females than males (Fig. 2g-h). These results may merely reflect the greater number of females participating in our study.

Fig. 2 a-h Local knowledge on uses of moringa based on age and gender among rural communities of Limpopo Province



Qualitative Results and Discussion on Moringa Usage

Our respondents provided qualitative data that allowed a deeper understanding of moringa usage and perceptions (Table 5).

Medicinal Uses of Moringa

Participants reported using moringa as a cure and for treatment and prevention of about 56 diseases, disorders, and ailments (Table 6). In this theme we identified five subthemes: treatment and prevention for chronic diseases; cure, treatment, and prevention for acute diseases and disorders; cure, treatment, and prevention of other common ailments; sexuality and fertility; and incorporation in traditional medicinal practices. The therapeutic potential of this tree affords a relatively cheap and reliable medicine to people in rural communities with insufficient funds and resources.

Treatment and Prevention of Chronic Diseases

Moringa is used to treat and prevent chronic diseases such as high blood pressure, diabetes, heart conditions, cancer (lung, leg, womb, and skin), anaemia, arthritis, asthma, migraines, and ulcers. One participant () noted: “It is a medicine; moringa has the ability to treat high blood pressure, sugar diabetes and cancer” (C.13). Another participant said: “I had asthma, but after drinking moringa I am now healed...” (W.02.). Others mentioned that moringa purifies blood, reduces the occurrence of heart failure, stroke, and kidney failure. Moringa trees are recognized as possessing anti-inflammatory, anti-cancer, anti-diabetic, abortifacient, antioxidants, and antimicrobial (fungal and bacterial) properties and their traditional medicinal uses are widely reported in other studies (see, e.g., Ramachandran et al., 1980; Anwar et al., 2007; Kasolo et al., 2010; Mehta et al., 2011; Kwaambwa et al., 2012; Kola-Oladiji et al., 2014;

Stevens et al., 2015; Brillhante et al., 2017; Padayachee and Bajjnath, 2020; Seifu and Teketay, 2020).

Moringa leaves contain high levels of calcium and potassium, which are beneficial to individuals suffering from arthritis (Moyo et al., 2011). Accordingly, Tate and Mowa (2020) suggest that moringa could be an alternative therapy to treat arthritis due to its ability to mitigate the expression of proteins involved in the pathogenesis and development of arthritis (i.e., inflammation, oxidative stress, and proliferation). Simultaneously, moringa increases the expression of proteins with potentially defensive properties such as anti-inflammation and apoptosis (Kou et al., 2018; Tate & Mowa, 2020). Our participants also regard moringa as a high source of energy and nutrients and it is often given to HIV/AIDS patients for a balanced diet. Our findings were corroborated by those of Dieye et al. (2008), who suggested regular intake of moringa by HIV/AIDS patients among ethnic groups in Nigeria and advocated for the broad usage of the plant. However, it is imperative to note that most of these claims have not been scientifically proven on human subjects; and thus require further investigation to explore its efficacy in the treatment, management, and prevention of chronic and non-communicable diseases.

Prevention, Treatment, and Cure of Acute Diseases and Disorders

Our respondents use moringa to treat diseases and disorders such as common cold, influenza, fever, chickenpox, eye and ear infections, blood clotting, nose bleeds, stomach pain/cramps, urinary tract infections, shortness of breath, lower respiratory tract infections, heartburn, chest complaints, rash, sores, allergies, constipation, acute insomnia, itching eyes, insect bites, pain (body, kidney, waist, and joints), and painful and swollen legs. One participant said: “...Moringa healed me from painful sores which were in my intestines... Moringa has many uses such as medicine for rash, fever, joint pains...” (C.16). These findings reflect those of Seifu and Teketay (2020) and Kwaambwa et al. (2012) in

Table 5 Themes and sub-themes extrapolated using participants’ responses about moringa uses in Limpopo province, South Africa (Total sample N = 106)

Themes	Sub-themes
Medicine	Treatment and prevention for chronic diseases Prevention, treatment, and cure for acute diseases and disorders Prevention, treatment, and cure for other common ailments Sexuality and fertility Incorporation in traditional medicinal practices
Nutrition	Fresh and dried moringa Processed moringa
Livestock feed	Nutritional supplement Improving livestock fertility
Beauty and cosmetic use	Anti-ageing Removal of sores and scars

Table 6 Medicinal uses of moringa by rural communities of Limpopo Province, South Africa

Category of medical conditions	Diseases, ailments and disorders	Purpose of moringa use	Moringa part/s used	
Chronic diseases	High blood pressure	Treatment, prevention	Leaves, seeds	
	Diabetes	Treatment, prevention	Leaves, seeds	
	Womb cancer	Treatment, prevention	Leaves	
	Skin cancer	Treatment, prevention	Leaves, seeds	
	Lung cancer	Treatment, prevention	Leaves	
	Asthma	Cure, prevention	Leaves	
	Arthritis	Cure, prevention	Leaves	
	Migraine headache	Cure, prevention	Leaves	
	Heart failure	Treatment, prevention	Leaves	
	Stroke	Prevention	Leaves	
	Anaemia	Treatment, prevention	Leaves	
	Kidney failure	Treatment, prevention	Leaves, seeds	
	Ulcer	Treatment, prevention	Leaves	
Acute diseases and disorders	Common cold	Cure, prevention	Leaves	
	Flu	Cure, prevention	Leaves, roots	
	Fever	Cure, prevention	Leaves, roots	
	Chicken pox	Treatment	Leaves, seeds	
	Rash	Treatment	Leaves, seeds	
	Sores	Treatment	Leaves, seeds	
	Insect bite	Treatment	Leaves	
	Swollen legs	Treatment	Leaves	
	Short breath	Cure, prevention	Leaves	
	Lower respiratory tract	Cure, prevention	Leaves	
	Ear infections	Treatment	Leaves	
	Eye infections	Cure	Leaves	
	Itching eyes	Cure, prevention	Leaves	
	Body pains	Cure, prevention	Leaves, seeds	
	Stomach pains	Cure, relieve	Leaves	
	Waist pains	Cure, prevention	Leaves	
	Joint pains	Cure, prevention	Leaves	
	Painful legs	Cure, prevention	Leaves	
	Chest complaints	Cure, relieve	Leaves, seeds	
	Allergies	Treatment	Leaves	
	Constipation	Treatment, cure	Leaves, roots	
	Heartburn	Cure, prevention	Leaves	
	Nosebleed	Cure	Leaves	
	Blood clotting disorder	Cure	Leaves, seeds	
	Urinary tract infections	Cure, prevention	Leaves	
	Other common ailments	Fatigue	Reduces fatigue	Leaves
		Hyperhidrosis	Treatment	Leaves
Trimethylaminuria		Treatment	Leaves	
Weight loss		Helps with weight loss	Leaves	
Short-sightedness		Cure	Leaves	
Bedwetting		Cure	Leaves	
Insomnia		Promotes sound sleep	Leaves	
Sexuality and fertility	Digestive disorders	Treatment	Leaves, seeds	
	Infertility	Cure	Leaves	
	Low libido	Treatment	Leaves	
	Erectile dysfunction	Cure	Leaves	
	Weak erection	Cure, prevention	Leaves	
	Early ejaculation	Treatment, prevention	Leaves	
	Low sperm count	Cure, prevention	Leaves	
	Dysmenorrhea	Treatment, prevention	Leaves	
	Irregular menstrual cycles	Cure, prevention	Leaves	
	Vaginal infections	Cure, prevention	Leaves	
Problematic vaginal discharge	Treatment, prevention	Leaves		

Botswana and Swaziland, and those of Stevens et al. (2013) and Bancessi et al. (2020) in Nigeria and Guinea-Bissau. According to D'souza and Kulkarni (1993), moringa can be used to treat scorpion, insect, and snake bites and to reduce inflammation due to its detoxification and anti-inflammatory properties (see also Kou et al., 2018).

Prevention, Treatment, and Cure of Other Common Ailments

Our participants stated that moringa reduces abnormal sweating habits (hyperhidrosis), diminishes bad body odour (Trimethylaminuria), loosens stiff muscles, reduces fatigue, treats short-sightedness, promotes sound sleep, cures bed-wetting, cleanses and detoxifies the body, strengthens the immune system, aids weight loss, is a laxative, and treats digestive disorders. One participant said: “I now have better sleeping habits since I started using moringa...” (M.17) (see also Shimizu et al., 2019 (Japan) and Seifu and Teke-tay, 2020 (Botswana). Moringa medicinal products (i.e., pills, capsules) are available at local markets, pharmacies, and street vendors in South s and health benefits of moringa are widely recognised by communities in the Limpopo Province.

Sexuality and Fertility

Our participants reported that moringa is used to improve fertility among both men and women and served as an energy booster during sexual intercourse. For men, moringa was used to stimulate sexual desires, performance, and arousal. It was perceived as a remedy for early ejaculation in men. Some participants mentioned that moringa was used to cure erectile dysfunction, weak erections, low sperm count, and impotence. Other participants stated that many families had been restored because of moringa use. Consequently, moringa had been given the local name of *Motsošo* (Sepedi word that means the one that raises or restores). One participant stated: “Moringa serves as an energy booster during sexual intercourse. It prevents early ejaculation, erectile dysfunction and corrects the issue o weak erection as well as other diseases and disorders that affect sexual intercourse...” (C.18) (cf. Kola-Oladiji et al., 2014). Respondents also mentioned that moringa improves chances of conception in women experiencing fertility issues and can treat abdominal cramps associated with menstruation (dysmenorrhea), as well as the restoration of ceased and/or irregular menstrual cycles. Additionally, moringa was used to treat vaginal infections and problematic discharge (see also Kasolo et al., 2010 (Uganda) and Stevens et al., 2015 as well as Popoola and Obembe, 2013 (Nigeria). These uses of moringa need to be analysed thoroughly and comprehensively through a

sound scientific examination on human subjects to validate their effectiveness.

Incorporation in Traditional Medicinal Practices

Several traditional healers responded to our surveys and indicated that moringa was incorporated in their traditional medical practices. One stated: “As a traditional healer, I give people moringa to get healed as I would have consulted and received an approval from my ancestors ...” (V.14) (cf. Semenya et al., 2012). Rural people are frequently reliant on traditional healers not only by preference but also because of limited access to modern medical facilities, high costs of modern medicines, and intolerable queues at clinics and hospitals (Hossan et al., 2010). Furthermore, most traditional healers live in the same villages as their patients, who are consequently more comfortable in obtaining treatment from them (Morris, 2002; Moeng, 2010). According to D'souza and Kulkarni (1993), almost all moringa parts are used in traditional medicine practices. However, there is a paucity of clinical trials conducted on the efficacy of moringa for all the medical uses that community members described.

Moringa as a Food Source

Our respondents indicated that they consume moringa in three different forms we divided into two subthemes: (i) fresh and dried moringa; (ii) as processed moringa.

Fresh and Dried Moringa

Participants indicated that they commonly use dried-leaf powder and crushed moringa seeds as a spice in daily foods such as relish, meat, indigenous vegetables, spinach, cabbage, soft porridge, and potatoes. One participant noted: “We grind the dry leaves into powder which we use in foods as spice... I add a teaspoon of moringa powder in my food” (W.06) (cf. Popoola and Obembe, 2013; Stevens et al., 2013; Palada, 2017; Neergheen-Bhujun et al., 2020). Our participants also described eating moringa seeds as a raw snack like peanuts (cf. Duke, 1983 (Malaya) and Neergheen-Bhujun et al., 2020 (Mauritius). Moyo et al. (2011) suggested that the high nutritional properties of dried moringa leaves are an indication of their importance as a food source to mitigate malnutrition, but also a rationale to establish moringa as a cultivated food (Ma et al., 2020) that could also generate household income and create jobs for marginal communities throughout South Africa at large thus contributing to achieving the Sustainable Development Goals of Good Health and Well-being, Zero Hunger, and No Poverty.

Processed Moringa

Participants consumed moringa in the form of various products such as moringa juice, instant porridge, moringa chocolate bar, various flavoured shakes, iced tea, tea bags, moringa leaf powder supplements, yoghurts, seed oil (ben oil), non-alcoholic beverages and energy drinks. A participant (**M.03**) gave the following response: “*People make powder; there is moringa yoghurt, chocolate, moringa instant porridge and moringa milkshakes*”. The variety of moringa food products sold at local supermarkets and by street vendors in Limpopo province was reported in a previous study by Lekgau (2011) and this wide food usage suggests the recognition of this plant as *Makgonatsohle* (Sepedi word for healing everything or ability to do all things) by rural communities and commercially. However, moringa food products are still underutilised and yet to be fully exploited nationally. There is therefore a need to promote awareness on the nutritional importance of moringa among marginal communities. In addition, guidance and training on the processing and incorporation of moringa in foods is necessary to ensure responsible and safe use.

Moringa as Livestock Feed

Our participants stated that they used moringa leaves as livestock feed for goats, cattle, pigs, and poultry (cf. Price, 2007; Popoola and Obembe, 2013; Babiker et al., 2016; Mabusela et al., 2018; Bancessi et al., 2020). Sarwatt et al. (2002) concluded that moringa has the potential to replace conventional livestock feeds such as sunflower seedcake and alfalfa. We identified two sub-themes: nutritional supplement and improved livestock fertility.

Livestock Nutritional Supplement

Participants reported numerous benefits of moringa fodder for livestock such as weight gain, improved milk production, reduced incidence of diseases, and improved fertility, as well as an important source of animal nutrition during drought periods. This is confirmed by Banjo (2012) who recorded improved weight gain of broiler chicks fed with moringa leaves as a dietary supplement. Price (2007) had similar findings for daily weight gain of beef cattle and milk yields of dairy cows, which increased by 30% with moringa leaves as 40–50% of their fodder. Sanchez et al. (2006) also reported that supplementing guinea grass fodder with moringa increased weight gains of sheep.

Livestock Fertility

In relation to improving livestock fertility, one participant reported: “I had two pigs which were old and infertile. I decided to give them moringa and now they made lots of piglets...” (**M.03**). We are not aware of any studies of the cultural use of moringa to treat livestock infertility, but strongly argue that such studies should be undertaken for the benefit of marginal communities that have limited resources and means to deal with livestock infertility.

Beauty and Cosmetic Use

Our respondents reported several beauty products incorporating moringa including moringa petroleum jelly, hair food, bath soaps, tissue oils, moringa body butter, lip balm, and body lotions. These products are used to treat various skin conditions such as the removal of scars and blemishes, reducing wrinkles and the appearance of ageing, as well as maintaining healthy skin. We identified two subthemes: (i) anti-ageing, and (ii) removal of sores and scars. Some participants said that they looked younger after using moringa products, and “appeared more attractive.” One participant described how moringa oil and leaf powder “... are both used on the face to reduce wrinkles, sores and make one to look younger...” (**M.04**) (cf. Marcu, 2005; Kola-Oladiji et al., 2014). The incorporation of moringa seed oil into skin care products is one of the most recent developments in the cosmetics and skin care industry in South Africa (Rahaman et al., 2017; Ali et al., 2018). Moringa seed oil is very light and is absorbed quickly by the skin and provides it with essential nutrients (Kleiman et al., 2008) due to high oleic acid levels in moringa (Guon & Chung, 2017).

Knowledge About Invasive Alien Species and Government Regulations

Only about a quarter of participants (24%) knew about NEM:BA and alien invasive species, whereas the majority (76%) were unaware of them prior to participating in the study (Table 7). However, those who were able to list invasive species could only provide vernacular names of snakes, fish, birds, and plants. When asked about impacts of alien or invasive species on the ecosystem, about 70% were unaware of any. This suggests that there is huge knowledge gap and lack of government engagement to make the rural study communities aware of alien species and their impacts on ecosystem services.

Many participants (78%) said they would be very dissatisfied should the government decide to restrict or eradicate moringa. These results reflect those of Irlich et al. (2017) who emphasised that the awareness of alien invasive species

Table 7 Knowledge of respondents on government legislations concerning alien invasive species (Total sample N = 106, and N = 106 presented by category)

Variables	Response	Frequency	%
Knowledge of NEM:BA	Yes	26	24
	No	80	76
Knowledge of alien invasive plants	Yes	26	24
	No	80	76
Impact of invasive species	Positive impact	13	12
	Negative impact	6	6
	No impact	13	12
	I don't know	74	70
Feeling about moringa restriction/eradication	Satisfied	2	2
	Neither	5	5
	Dissatisfied	16	15
	Very dissatisfied	83	78

Table 8 Knowledge of alien species and government legislatures by age and gender (Total N = 106)

Variables		χ^2	DF	P	Phi/ Cramer's V
Age	Knowledge of NEM:BA	7.106	5	0.213	Phi = 0.26; V = 0.26
	Knowledge of invasive species	3.068	5	0.689	Phi = 0.17; V = 0.17
	Knowledge impact of invasive species	13.731	15	0.546	Phi = 0.36; V = 0.21
	Feelings on moringa eradication/ restriction	8.811	15	0.887	Phi = 0.29; V = 0.17
Gender	Knowledge of NEM:BA	4.308	1	0.308	Phi = 0.20; V = 0.20
	Knowledge of invasive species	2.584	1	0.108	Phi = 0.16; V = 0.16
	Knowledge impact of invasive species	3.283	3	0.350	Phi = 0.18; V = 0.18
	Feelings on moringa eradication/ restriction	3.405	3	0.333	Phi = 0.18; V = 0.18

impact is mostly poor, and the knowledge of the requirements set out by NEM:BA regulations is scanty throughout South Africa. Knowledge about government legislation (NEM:BA), invasive species and their impacts, as well as attitudes towards moringa eradication or restriction were not associated with age and gender, with the strength of association being weak for all variables (Table 8).

Participants above the age of 60 years had no knowledge about NEM:BA, invasive species, and/or their impact (Fig. 3a-d), even though our results were not statistically significant. This age group was also the most dissatisfied when asked about their attitudes on eradicating or containing moringa in South Africa. In terms of gender, more females than males had not heard about NEM:BA, invasive species, and their impacts, and exhibited strong disapproval of moringa eradication or restriction by the government (Fig. 3e-h). These results illustrate that there is a knowledge gap on biological invasions among both males and females of all age groups in rural communities of Limpopo Province. The management interventions of alien species such as moringa that these communities use for various purposes could become a cause for conflicts should they be enforced in the face of local opposition (Kaplan et al., 2017; Zengeya et al., 2017). Rather, such interventions should be informed by local perceptions and uses of the plants.

Qualitative Results and Discussion on Knowledge of Alien Species and Government Regulations

Our participants pointed out that assigning moringa to an impact category could have negative effects on socio-economic aspects and their livelihoods. The inclusion of this qualitative data could allow further explanations as to how rural communities of Limpopo Province might be affected should moringa be allocated an impact category (Table 9).

Our participants indicated that they would be deeply dissatisfied should moringa be eradicated or restricted. They reasoned that moringa was *makgonatšohle* (having the ability to do everything) in their lives, with some farmers reporting that their business would be greatly impacted, and their employees would lose their source of income. One participant observed: "I will be very displeased because this will affect the income of farmers and sellers negatively and our nutrition since moringa has some nutrients which we are not able to get from our normal daily intake of food" (M.16). Another mentioned that: "...the government should consult with us in their decision, and they must provide us with a better alternative of moringa" (V.15). These responses reveal a significant lack of communication between government bodies and communities regarding listing species such as moringa under NEM:BA.

Fig. 3 a-h Local Knowledge of alien species and government regulations based on age and gender by rural communities of Limpopo Province

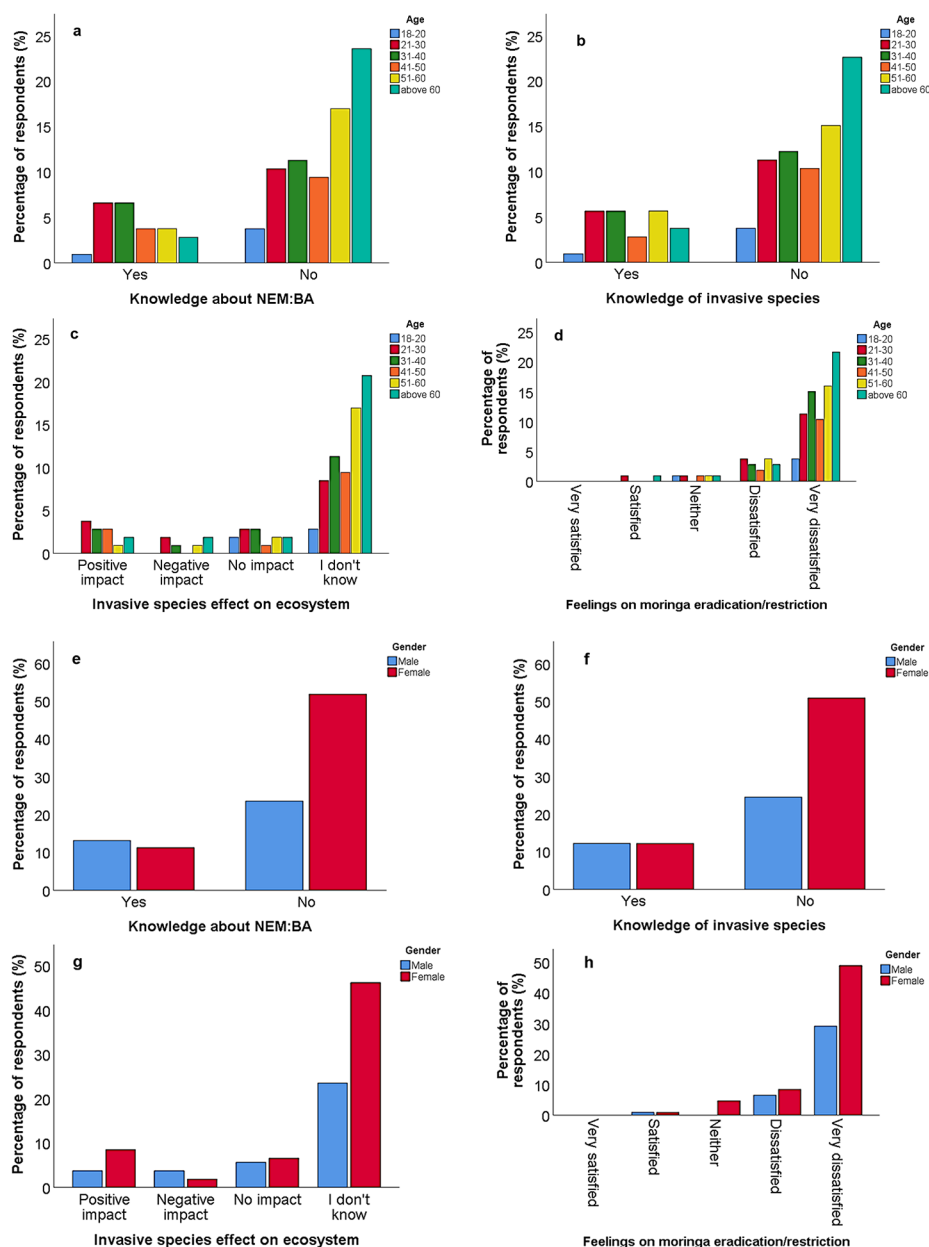


Table 9 Themes and sub-themes on perceptions of respondents on the legal status of moringa in the Limpopo Province, South Africa (Total sample N = 106)

Themes	Sub-themes
Socio-economic impact	Loss of income by moringa farmers and sellers Loss of jobs by moringa farm employees
Health impact	Loss of accessible high-nutrition source Concerns about their health status

Although South Africa has legislation that monitors the management of biological invasions, interventions are difficult to implement because of the potential conflicts of interest and perceptions of value amongst different communities (Kaplan et al., 2017). Therefore, assessing social perceptions provides a broad understanding of the adverse effects of invasions as well as communities’ attitudes, desires and requirements that are directly or indirectly affected by management interventions (Shackleton et al., 2017). Assessments of this nature are important for justifying management interventions of targeted species that have potential benefits to sectors of society (van Wilgen and Richardson, 2014; Mashamaite et al., 2020). This is because

species such as moringa are beneficial particularly to marginal rural communities that rely on the plant for health and socio-economic benefits.

Nevertheless, when asked about the invasive potential of moringa, all the participants argued that they have not seen moringa trees growing in areas where the surrounding ecosystems have been negatively affected. According to Estevez et al. (2014), not all alien species are invasive; rather, some provide basic resources for local communities and industries. This implies that moringa should not be treated like other alien species such as pine, eucalyptus, and acacia trees in South Africa, which have adversely affected biodiversity (van Wilgen, 2012). Additionally, moringa's invasive potential has not yet been recorded in South Africa or elsewhere across the globe.

Overall, the listing of species such as moringa under NEM:BA for eradication or control has the potential to cause conflicts between lawmakers and local communities who use moringa for various purposes. The inclusion of local communities with distinct indigenous knowledge and perceptions as well as socio-cultural perspectives could aid in promoting efficiency and trust among all affected stakeholders (Shackleton et al., 2019), help with conflict resolution, and ensure there is evidence to support local and broader scale decision-making processes in invasive species management interventions.

Conclusion

Our study showed that moringa is widely recognized, highly valued, and used for a range of purposes among rural communities in Limpopo Province, South Africa. Although moringa is considered an introduced species, it is widely recognized and is mainly associated with positive perceptions. Our findings indicate that moringa is used chiefly for treatment and prevention for numerous medical conditions; as a nutritional food source; as livestock fodder and shade; as well as for beauty and cosmetic products. Considering potential uses of moringa elsewhere in South Africa, we argue that there is an urgent need to encourage its utilisation countrywide. However, its efficacy for all these uses needs to be explored widely through sound scientific investigations to establish their effectiveness on human and animal subjects. Knowledge about alien invasive species and NEM:BA regulation was poor among our participants, who indicated that eradicating or restricting access to moringa could negatively affect their livelihoods and well-being, and could thus potentially cause conflicts of value and interest between rural communities and government authorities. Additionally, achieving the Sustainable Development Goals (SDGs) of Zero hunger, Poverty Alleviation, and Good

Health and Well-being by these communities using moringa could be hindered by government restrictions. Local ecological knowledge should be recognised as an important element in understanding attitudes and perceptions as well as developing effective management strategies concerning ecosystem services and human well-being. In future, policy-makers should adopt a holistic approach that acknowledges indigenous knowledge and perceptions for justifying their decision-making in listing species that are important to marginal communities.

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Authors' Contributions CVM, EEP, and PNM conceived and designed the experiment. EEP acquired funding for the study. EEP, PJP, PNM, and AJA were co-supervisors of the PhD graduate CVM. With the assistance of AJA, CVM designed the methodology and conducted the study. PNM and CVM analysed the quantitative data and interpreted the results. AJA supervised CVM with the qualitative data analysis. CVM drafted the manuscript, and all authors discussed the results, read, and approved the final manuscript.

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Data Availability The dataset generated during the current study is not publicly available as it contains proprietary information that the authors acquired through permission from Stellenbosch University's Research Ethics Committee. Data were stored at Stellenbosch University's repository in line with the internal data management plan (<https://library.sun.ac.za/en-za/Research/rdm/Pages/rdm-su.aspx>), compliant with Protection of Personal Information (POPI) Act No. 4 of 2013 (Information Regulator South Africa, 2013). However, diary notes and information on how to obtain and reproduce the analysis are available from the corresponding author upon reasonable request.

Declarations

Competing Interests 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.

Ethical Approval and Consent to Participate The study complied with the Stellenbosch University's policy on research ethics and permission was received from the University's Research Ethics Committee (REC: 2018–7868) prior to data collection to ensure that the research was ethically conducted. Stellenbosch University policies, appropriate

legal framework and ethical considerations were adhered to during and beyond completion of this study.

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