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Nutritional composition of wild sour plum (*Ximenia caffra subs caffra)* fruit harvested in varying geographical regions and its potential role in human nutrition

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Abstract

By 2030, the United Nations, through their Sustainable Development Goals (SDGs), hope to have eradicated hunger and malnutrition, ensuring that everyone has access to enough nutritious food throughout the year. This is especially aimed at developing countries. There is untapped potential for food and nutrition security in Africa's wide variety of native fruit trees. One example of a wild fruit tree that is underutilised is the wild sour plum (*Ximenia caffra subs caffra)*, a fruit crop from the Oleaceae family that grows in the Southern Africa. The objective of the study was to determine the nutritional variation of the wild sour plum, harvested from varying geographical regions, to possibly assist the potential breeders' suitable methods for selecting accessions that could be used for potential breeding of highly nutritious fruit crop. Ripe wild sour plum fruit were harvested from varying plant selections in three different regions (Bushbuckridge, Giyani, and Tzaneen) during December 2022. Dried, frozen samples were analysed for biochemical constituents, such as total phenols and vitamin E. The highest total phenols (17.2 GAE g) and vitamin E (31.8 mg 100/g DW) of wild sour plum were obtained from selection three (3) fruit in Bushbuckridge. Therefore, plant breeders and horticulturalists should be mindful of these factors when considering breeding programmes of wild sour plum for commercial purposes.

Article highlights

- Nutritional contribution: Contribution to nutrition: *X. caffra* fruit, high in vitamins, calcium, and zinc, has a wealth of nutritional benefits.
- Value-addition: Findings emphasise the necessity of cultivating *X. caffra* fruit and commercialising its value-added products.
- Zero Hunger contribution: *X. caffra* fruit contain vital nutrient and can assist in speeding up the 'Zero Hunger' SDG initiative.

Keywords Sustainable development goals · Malnutrition · Underutilised crops · Total phenols · Vitamin E

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1 Introduction

The combination of factors, such as the environment and plant selection, which is the reliable process of selecting plants with desirable traits, determines the nutritional concentration of various fruit crops [1]. This technique is mostly used for crop improvement programmes [2]. Most rural communities with limited resources and access to nutritional food in Southern Africa depend on indigenous crops as a source of food for sustenance [2]. However, it has been reported that many rural households experience a significant nutritional problem due to deficiency of various macro and micro-nutrients such as calcium, potassium, zinc, iron, and beta-carotene [1, 3]. The advantages of indigenous crops have been reported by researchers such as [1] and [4], as being (i) their ability to grow naturally in the wild, (ii) their resistance to most pests and diseases, (iii) their improved ability to withstand environmental stress, (iv) their low reliance on agricultural inputs like irrigation and fertilizers, and (v) their quick maturation and ready availability for consumption. An ongoing quest for "new" crops that may be added to the food supply and potential commercialisation is essential to addressing the world's food and medicinal shortages [5]. This emphasises the need to introduce alternative crops that perform well under adverse conditions to meet the nutritional and medical demand globally [6]. In recent years, studies on climate change adaptation have focused notably on the utilisation of underutilised food crops, including wild edible fruit species [1]. As a result, the Sustainable Development Goals have garnered more interest towards eradication of hunger under the slogan 'Zero Hunger') through improving the use of underutilised crops. One example of such crop that is underutilised is the wild sour plum (*Ximenia caffra subs caffra)*, a fruit crop from the Olacaceae family that grows in Southern Africa. In terms of utilisation, several studies reported that ripe sour plum contain potassium, protein, and vitamin C [7–9]. Even though other factors, including soil type, plant age, and genetic diversity also play a significant impact in the biochemical composition of the plant. Studies have pointed to climatic conditions as one of the main contributors to the nutritional content of most fruit crops [10]. Numerous studies, for instance [1, 5, 11, 12], have revealed that variations in temperature, solar radiation, water availability, and other climatic factors have a direct impact on biochemical components of fruits, including soluble solids, vitamin content, phenolic compound content, and micronutrients. Although, numerous reports by [7, 13], shown that wild sour plum fruit is rich in vital mineral and used as a raw material to make value-added products such as jam and jellies by-rural communities in Southern Africa, there is scanty literature on the impact of varying geographical variation on its nutritional content. Therefore, the study objective was to determine the nutritional variance of wild sour plums harvested from varying geographic regions (Bushbuckridge, Giyani, Tzaneen), so that comparative analysis could be done to assist potential breeders select desirable accessions for potential breeding programmes of highly nutritious wild sour plum fruit crop.

2 Materials and methods

Following the method of [6], fifty-four (54) trees were sampled using a cluster randomized sampling technique in three different locations (Bushbuckridge, Giyani, and Tzaneen) with slightly modification. The prevalence and usage of wild sour plum trees in these locations dictated the selection of sampling areas. About 18 trees were sampled from each location, resulting in 54 trees. The population as a whole was divided into groups of six trees in each selection per geographical area. A total of 18 trees were sampled for each location, which included six (6) trees from each selection, spaced thirty (30) meters apart. From each selection, eight (8) fruits were collected from each tree, which yielded to a total of 432 fruits. Ripe wild sour plum fruit, as shown in Fig. 1, harvested from varying plant selections that were approximately a minimum of 1 km apart in three different areas, (i) Bushbuckridge, Huntington (− 24.91648, 31.41572), (ii) Giyani, Makoxa village (− 23.31748, 30.72255) and (iii) Tzaneen, Nwamitwa village (− 23.73398, 30.36925) during December 2022 (Fig. 2). The vegetation type of Bushbuckridge, Giyani and Tzaneen is classified as Bushveld, which is a mixture of grassland and trees, with low to medium annual rainfall (Table 1). Only fully ripe and well-developed non-fallen fruits were collected for nutritional analysis using the procedure outlined by [8]. The fruit colour chart developed by [14] was used as a reference to determine the ripeness of the fruit. Harvested fruits were then transported to the Agricultural Research Council-Institute for Tropical and Subtropical Crops, Mbombela station, Mpumalanga Province (− 25.8990023 S 28.2152523 E.). On arrival, fruits were sorted manually for uniformity of colour, shape, size, and defects. Before sample preparation, fruits were washed with 0.02% sodium

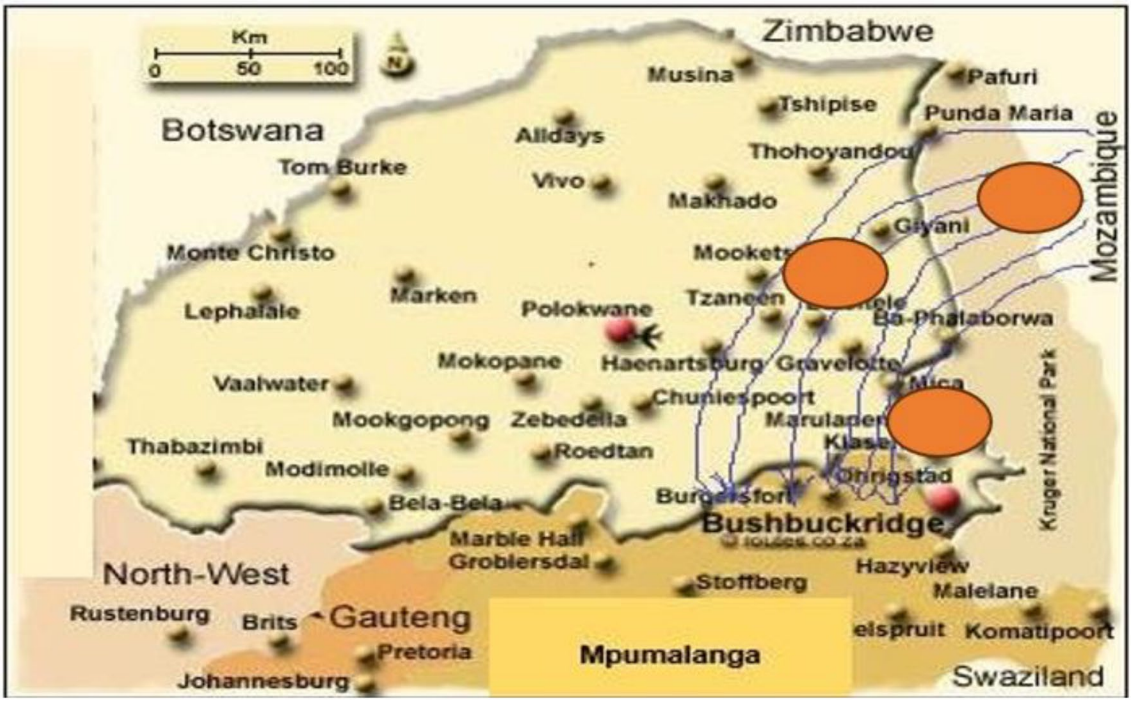

Fig. 1 Unripe and ripe fruit of wild sour plum

Fig. 2 Study area map (Bushbuckridge, Giyani, Tzaneen) generated using google maps (Global positioning system coordinates-GPS) taken from study areas

Table 1 Soil mineral composition of three study areas

	Mineral composition analysis								
	Fe	Mn	Cu	Zn	P	Ca	Mg	K	Na
Bushbuckridge	27	10	10	17	27	1120	188	151	54
Giyani	33	15	7	12	20	1471	221	189	47
Tzaneen	38	17	14	15	25	1528	223	223	58

Bushbuckridge means location one (L1). Giyan means means location two (L2). Tzaneen means location three (L3) hypochlorite (NaClO) for one minute to disinfect them. After disinfection and air drying, fruits were peeled with a sharp sterilised knife to separate pulp and seeds. Fruit pulps were frozen at – 80 °C for two days before being freeze dried. A freeze dryer (VirTis Co., Gardiner, NY, USA) was used to freeze dry fruit pulps, with a condenser temperature of – 88.7 °C and a vacuum pressure of 7mTorr. Samples were then pulverised using mortar and pestle and stored until analysis. The experiment was conducted strictly in compliance with the University of South Africa (UNISA), College of Agriculture and Environmental Sciences Research and Higher Degree Committee (Ethical number/Reference #: 2022/CAES HREC/104), and other local and global relevant regulations.

2.1 Meteorological data

Table 2 depict the Meteorological data of study areas (Bushbuckridge, Giyani, Tzaneen).

2.2 Nutritional analysis

Nutritional composition of wild sour plum fruit harvested from different plant selection and geographical regions was evaluated during the summer of December 2022. A total of 144 fruit were used for the analysis of beta carotene, vitamin E, lycopene, total soluble sugars, total flavonoids, total phenols, vitamin E, macro and micro-nutrients. For beta carotene, which was expressed in milligram per 100 g (mg/100 g) of dry weight (DW), the method developed by [1, 15, 16], according to the procedure of [1, 16] was utilised with minor modification. Regarding vitamin E, which was expressed in mg/100 g DW, the method developed by Irakli et al. (2016) was adopted with minor modification. Concerning total soluble sugars (TSS) content, expressed in ˚Brix, [1], method adopted by [8, 17] was utilised. For pH, the analysis was done following the method used by [15, 17] with slight modification. Regarding total flavonoids, expressed in mg catechin equivalents (CE) per dry weight (DW), the method reported by [17]. For determination, total phenols content, expressed in mg of garlic acid equivalents (GAE) per grams of dry weight (DW), [18, 19] and [20, 21] methods were used. Regarding the macro and micro-nutrients content, expressed in mg/100 g DW, [16, 20–22] method, adopted by [4] was utilised.

Table 2 Meteorological of study areas (Bushbuckridge, Giyani, Tzaneen)

	T_{max} (°C)	T_{min}	Rainfall (mm)
Bushbuckridge (L1)			
Month			
September	30 °C	13 °C	27,2
October	31 °C	16 °C	97,1
November	32 °C	19 °C	79,3
December	33 °C	20 °C	140,3
January	34 °C	22 °C	172,5
			516.4
Giyani (L2)			
September	28 °C	16 °C	10
October	31 °C	18 °C	22
November	32 °C	19 °C	68
December	33 °C	19 °C	119
January	35 °C	21 °C	118
			337
Tzaneen (L3)			
September	29 °C	17 °C	34
October	31 °C	18 °C	59
November	31 °C	19 °C	123
December	33 °C	19 °C	164
January	34 °C	20 °C	163
			543

L1 means location one (Bushbuckridge). L2 means location two (Giyani). L3 means location three (Tzaneen)

The nutritional content analysis methods utilised in this study were slightly different from those of other authors in that each analysis was carried out in triplicate.

2.3 Statistical analysis

A one-way analysis of variance (ANOVA) was used to analyse data on the nutritional content of wild sour plum fruit harvested from different plant selection under varying geographical regions. The variables measured included beta carotene, vitamin E, lycopene, total soluble sugars, total flavonoids, total phenols, vitamin E, macro, and micro-nutrients. The least significant difference (LSD) was considered for all studied variables. StatSoft (USA) version 10 was utilised for all statistical analysis.

3 Results and discussion

3.1 Biochemical constituents of wild sour plum and its potential role in human nutrition

3.1.1 Total soluble sugars and pH

The effect of varying plant selection on the total soluble sugars, and pH on wild sour plum harvested in differing locations as shown in Table 3. Results showed that there was significant ($P \geq 0.05$) difference in the amount of total soluble sugars and pH levels. Total soluble sugars content ranged from 16.2 to 18 ˚Brix. In addition, the study findings revealed that selection three, under the Bushbuckridge location, reduced total soluble sugar content from 18 to 16.2 ˚Brix, while fruits harvested from selection three under Tzaneen had increased total soluble sugars from 16.2 to 18 ˚Brix. Soluble sugars function as the body's main messengers, regulating signals that affect the expression of many genes involved in metabolism and growth [4]. Furthermore, it serves as the main energy source for essential internal organs including the brain, making it a crucial component of human survival [20]. The average between the lowest total soluble sugar content (16.2) and highest (18) was 17.1. This means that consumption of wild sour plum fruit has a potential to assist in the curbing of health complications such as shakiness, sweating, irregular heartbeat and constant fatigue, which are deficiency symptoms associated to low sugar intake in human diet. These findings concur with those of [1], who reported acceptable soluble sugar content of various underutilised edible fruits with potential dietary purpose. For pH, results showed that it ranged from 2.7 to 2.9. Moreover, study results showed that selection one fruit harvested from Tzaneen location had the lowest pH content of 2.7, while selection three fruit harvested from Bushbuckridge recorded the highest pH content of 2.9. The human body's optimal pH is mildly alkaline, which helps with some metabolic processes like oxygenating

Table 3 The effect of varying plant selection on the total soluble sugars, titratable acidity and pH on wild sour plum harvested in differing locations

Treatment	Total soluble sugars (˚Brix)	pH
Location and Selection		
BS1	17.2(0.2)	2.82(0.2)
GYS1	17(0.7)	2.84(0.7)
TZNS1	16.8(1.0)	2.87(1.0)
BS2	17.3(0.2)	2.86(0.2)
GYS2	16.2(0.6)	2.75(0.8)
TZNS2	17.3(0.1)	2.71(0.2)
BS3	18(0.6)	2.67(07)
GYS3	17.1(0.3)	2.74(0.3)
TZNS3	17.3(0.2)	2.7(0.27)
Grand Mean	17.1	2.8
$LSD_{0.05}$	0.54	0.03
P_{value}	**< 0.02**	**< 0.001**

BS mean Bushbuckridge. GY means Giyani. TZN means Tzaneen. S1 means selection one. S2 means selection two. S3 means selection three. The standard deviations of the mean are shown by numbers enclosed in brackets. Lower than 0.05 *P* values are in bold. The least significant difference between means, or LSD0.05, is used

the blood. This could mean that consumption of wild plum fruit may contribute to pH balance, which facilitates certain biochemical processes like provision of oxygen to the blood [20, 21].

3.1.2 Beta carotene, total flavonoids, total phenols, and vitamin E

The effects of various selections on the beta carotene, total flavonoids, total phenols, and vitamin E content of wild sour plum fruit harvested from different locations (Bushbuckridge, Giyani, and Tzaneen) are shown in Table 4. The findings of the investigation identified considerable ($P \leq 0.05$) variation. Regarding beta carotene, results showed that it ranged from 1.6 to 1.9 mg 100/g DW. Furthermore, study results illustrated that selection three harvested from Tzaneen contained lower beta carotene content of 1.6 mg 100/g DW, whereas selection three harvested from Bushbuckridge had higher beta carotene content of 1.9 mg 100/g DW. Beta carotenoids are regarded to be beneficial for health in lowering the risk of various diseases, especially malignancies and eye conditions [9, 23]. The average beta carotene content between the highest (1.9 mg 100/g DW) and lowest (1.6 mg 100/g DW) was 1.8 mg 100/g DW, while the daily recommended intake is 15 mg. Study results could mean that wild sour plum could potentially contribute about 12.6% beta carotene required by a human daily. Even though the values obtained in this study are lower than the recommended daily intake, consumption of wild sour plums may be able to assist in preventing conditions that may lead to fat malabsorption, pancreatic enzyme deficiency, gallbladder disease, and liver disease, which are symptoms linked to lower beta carotene intake in human nutrition [22, 23].

For total flavonoids, results showed that it ranged from 10.3 to 17.2 CE DW. Further analysis of the study's findings revealed fruits harvested from Giyani selection one had lower flavonoid content of 10.3 CE DW, but selection three fruits harvested in Bushbuckridge had the greatest flavonoid content of 17.2 CE DW. Flavonoids have a variety of health advantages, including anticancer, antioxidant and anti-inflammatory effects. They also have cardioprotective and neuroprotective properties [22, 23]. The average value between the lowest (10.3 CE DW) and highest (17.2 CE DW) was 13.8 CE DW. The quantity of flavonoids in wild sour plums has the potential to have an impact contribution to human nutrition. They may help avoid infections, frequent colds, excessive bleeding, and nosebleeds, which are all linked to low flavonoids in ham diet.

In terms of vitamin E, study results showed that it ranged from 15.6 to 31.8 mg 100/g DW. Furthermore, results delineated that selection three fruit harvested in Tzaneen had lower vitamin E content, while fruit harvested from Bushbuckridge selection 1 resulted in higher vitamin E content 31.8 mg 100/g DW. The variation between the highest vitamin E content (31.8) and recommended daily intake (17) was 14 mg. The study's results suggest that vitamin E from wild sour plum fruit may be almost twice as abundant as what humans need daily. Because of its role as an antioxidant, its contribution to anti-inflammatory processes, and its immune-stimulating activity, vitamin E has been discovered to be

Table 4 The effect of different selection on biochemical constituents' content of sour plum harvested in varying locations

Treatment	Beta carotene (mg/100 g DW)	Total flavonoids (CE DW)	Total phenols (GAE DW)	Vitamin E (mg/100 g DW)
BS1	1.58(0.4)	15.5(0.3)	66.5(0.2)	31.8(0.5)
GYS1	1.84(1.2)	10.3(0.1)	73.2(0.6)	18.7(1.3)
TZNS1	1.7(0.8))	15.3(0.5)	69.2(2.4)	17.7(3.1)
BS2	1.72(0.3)	14.1(0.2)	68.2(0.1)	15.6(1.4)
GYS2	1.57(1.4)	15.6(0.1)	62.1(0.20)	21.6(2.1)
TZNS2	2(0.3)	16.7(0.4)	62.9(2.4)	18.6(1.1)
BS3	1.92(1.4)	17.2(0.4)	76.1(3.3)	22.8(3.2)
GYS3	1.64(2.2)	14.5(0.2)	77.5(2.1)	19.9(2.4)
TZN	1.58(1.2)	15.9(0.4)	69.2(3.4)	20.9(1.4)
Grand mean	1.73	15.01	69.4	20.8
$LSD0_{0.05}$	0.13	0.199	3.14	3.65
P_{value}	**< 0.001**	**< 0.001**	**< 0.001**	**< 0.001**

BS mean Bushbuckridge. GY means Giyani. TZN means Tzaneen. S1 means selection one. S2 means selection two. S3 means selection three. The standard deviations of the mean are shown by numbers enclosed in brackets. Lower than 0.05 *P* values are in bold. The least significant difference between means, or LSD0.05, is used

beneficial in the prevention and reversal of different diseases [1]. Consumption of wild sour plum fruit could potentially assist in curbing diseases such as dementia and cardiac complications, which are conditions associated to lower vitamin E in human nutrition [1, 22]. However, to prevent vitamin E toxicity in human nutrition, which can cause persistent bleeding, muscle weakness, exhaustion, nausea, and diarrhoea, the ideal amount of wild sour plum fruit consumption must be determined.

Regarding total phenols, results revealed that it ranged from 62.1 to 77.5 GAE DW. Results further showed that combination of selection two from Giyani had lower total phenolic content, whereas combination of selection three from a similar location had higher phenolic content of 77.5 GAE DW. Antioxidants called phenolic compounds guard the body's diverse tissues against oxidative stress [22, 23]. Additionally, phenolic chemicals play a crucial role in defensive mechanisms of anti-inflammation and anti-ageing [13]. The average between the highest (77.5 GAE DW) and lowest (62.1 GAE DW) was 70 GAE DW. Values obtained in this investigation mean that consumption of wild sour plum could assist in curbing conditions such as hyperactivity and poor immune system, which are symptoms associated with low phenolic content in human body [8].

3.2 Macro and micro-nutrients

3.2.1 Calcium, magnesium, phosphorus, and potassium

Table 5 presents the effect of selections on the macro-nutrients (calcium, magnesium, phosphorus, potassium) content of wild sour plum harvested from varying regions. The study results showed significant ($P \le 0.05$) variation of macro-nutrients such as calcium, magnesium, and phosphorus. However, there was no significant ($P > 0.05$) difference on the potassium content. The calcium content ranged from 1785 to 2740 mg 100/g DW. Selection three fruit harvested in Giyani had the lowest calcium content (1785 mg 100/g DW), while selection two of Bushbuckridge recorded the highest calcium content of 2740 mg 100/g DW. Calcium is a mineral that is most frequently linked to strong bones and teeth, but also plays a crucial role in blood clotting, assisting with muscle contraction, and regulating regular heart rhythms and neuron activities [1, 22, 23]. The average calcium rate between the lowest (1785) and highest (2740) was 2263 mg, while the recommended daily intake is 1250 mg. This suggests that consumption of wild sour plums, which have twice as much calcium as the daily recommended amount, could help prevent diseases like osteoporosis, a condition where the amount and thickness of bone tissue deteriorate [2].

Regarding magnesium content, results demonstrated that it ranged from 474 to 998 mg 100/g DW. Additionally, results show that selection one fruit harvested from Bushbuckridge had a lower magnesium content of 474 mg 100/g DW, whereas selection two harvested in Giyani had the highest magnesium content of 998 mg 100/g DW. The human body requires magnesium as a nutrient to remain healthy [1, 22, 23]. Moreover, magnesium is necessary for a variety of bodily functions, including controlling blood pressure, blood sugar levels, muscle pressure, neuron function, as well as

Table 5 The effect of different selection on macro-nutrient content (mg 100 g DW) of sour plum harvested in varying locations

Treatment	Calcium	Magnesium	Phosphorus
BS1	2713(3.1)	474(46)	1676(75)
GYS1	2413(10)	744(10)	1518(64)
TZNS1	1829(126)	472(24)	1849(39)
BS2	2740(31)	681(74)	1675(15)
GYS2	2387(20)	998(7)	1970(73)
TZNS2	2050(101)	866(17)	1374(65)
BS3	2547(32)	769(14)	1273(30)
GYS3	1785(95)	870(71)	2180(21)
TZNS3	1954(143)	350(12)	1640(52)
Grand mean	2269	691	168
$LSD0_{0.05}$	136.4	71.8	186
P_{value}	**< 0.001**	**< 0.001**	**< 0.001**

BS mean Bushbuckridge. GY means Giyani. TZN means Tzaneen. S1 means selection one. S2 means selection two. S3 means selection three. The standard deviations of the mean are shown by numbers enclosed in brackets. Lower than 0.05 *P* values are in bold. The least significant difference between means, or LSD0.05, is used

the production of DNA, protein, and bone [22, 23]. The average magnesium value between the lowest (474 mg 100/g DW) and highest (998 mg 100/g DW) was 736 mg 100/g DW, while the recommended daily intake is 390 mg. This suggests that consumption of wild sour plum, which is three times higher than the recommended daily intake, could assist in the curbing of conditions such as constipation, muscle cramps and nausea, which are symptoms linked with low magnesium intake. Even though certain authors such as [1, 17, 22], reported that excessive consumption of magnesium does not present a health concern since the kidneys remove excess through urine, excessive magnesium intake via dietary supplements carries health hazards, like diarrhoea, nausea, and cramping in the abdomen. Therefore, to prevent health risks associated with an excessive magnesium found in wild sour plums it is essential to determine the optimum number of fruits to be taken in its raw or value-added forms.

Phosphorus content ranged from 1273 to 2180 mg 100/g DW. Selection three fruit from Bushbuckridge had the lowest phosphorus content of 1273 mg 100/g DW. The highest phosphors content (1273 mg 100/g DW) was obtained from selection three fruit harvested in Giyani. The production of bones and teeth in the human body is the primary role of phosphorus [22]. It is crucial for the body's use of fats and carbohydrates [1, 22, 24]. The average content between the lowest (1273) and the highest (2180) was 1727 mg 100/g DW, while the recommended daily intake is 4000 mg. This implies that wild sour plum may provide roughly 43% of the daily phosphorus required by humans daily. Even though phosphorus values obtained in this investigation were slightly lower compared to the daily recommended intake, consumption of wild sour plum fruit could assist in curbing conditions such as loss of appetite, still joins, bone pain, breathing challenges, and skin irritation, which are symptoms linked with low phosphorus intake [1, 23, 25, 26].

3.2.2 Copper and zinc

Table 6 presents the effect of plant selections on copper, iron, and zinc content of wild sour plum harvested from varying regions. Study results illustrated significant ($P \leq 0.05$) difference on the copper and zinc content of wild sour plum. Nevertheless, there was no significant ($P > 0.05$) difference on iron content. Concerning copper content, results showed that it ranged from 0.85 to 2.9 mg 100/g DW. In addition, results demonstrated that selection one fruit harvested from Giyani had lower copper content of 0.85 mg 100/g DW, while selection three from a similar location had the highest copper content of 2.9 mg 100/g DW. The average copper content between the highest (2.9) and lowest (0.85) was 1.9 mg 100/g DW), while the daily recommended intake is 10 mg. This implies that wild sour plum may provide roughly 19% of the daily copper needed by humans. Copper, an essential element in human nutrition is required for adequate growth rate, cardiovascular integrity, lung elasticity, neovascularisation, neuroendocrine function, and iron metabolism [26–28]. This means that consumption of wild sour plum may potentially assist in curbing conditions such as anaemia, low body temperature, osteoporosis, bone fractures, low white blood cell count, irregular pulse, loss of skin colour, and thyroid issues, which are all warning signs of a potential copper shortage in human diet.

Table 6 The effect of different selection on micro-nutrient content (mg 100 g DW) of sour plum harvested in varying locations

Treatment	Copper	Zinc
BS1	1.59(0.3)	113.4(8.3)
GYS1	0.85(0.2)	81.7(0.1)
TZNS1	1.88(0.1)	86.3(6.8)
BS2	1.19(0.4)	90.7(2.8)
GYS2	1.91(0.2)	72.8(6.6)
TZNS2	2.85(0.2)	97.7(8.8)
BS3	1.35(0.4)	78.7(10)
GYS3	2.39(1.1)	119.1(13.2)
TZNS3	2.5(0.5)	106(9.3)
Grand mean	1.83	94.1
$LSD0_{0.05}$	0.57	14.77
P_{value}	**< 0.002**	**< 0.001**

BS mean Bushbuckridge. GY means Giyani. TZN means Tzaneen. S1 means selection one. S2 means selection two. S3 means selection three. The standard deviations of the mean are shown by numbers enclosed in brackets. Lower than 0.05 *P* values are in bold. The least significant difference between means, or LSD0.05, is used

Concerning zinc content, results showed that it ranged from 72.8 to 119.1 mg 100/g DW. In addition, the study results illustrated that selection two fruit harvested from Giyani had the lowest zinc content of 72.8 mg 100/g DW, while selection three fruit harvested from similar location demonstrated higher zinc content to 119.1 mg 100/g DW. The average zinc content between the highest (119.1) and lowest (72.3) was 96 mg 100/g DW, while the recommended daily intake is at 9 mg. This implies that the zinc content of wild sour plum may be eight times higher than what is needed by people daily. Zinc plays a significant role in DNA synthesis, cell proliferation, protein synthesis, the repair of damaged tissue, and immune system support [28]. According to the results of this study, eating wild sour plums, which contain eight times more zinc than the daily required amount, may help prevent disorders like loss of taste and smell, which are signs of a zinc deficiency in human nutrition [19, 29–32]. Therefore, it is crucial to determine the ideal quantity of raw fruits to be consumed or in value-added products to avoid health hazards including liver issues, diabetes, stomach pain, and heart failure, which are linked to an excessive zinc content in human diet [1, 20, 21, 33–36].

4 Conclusion

The study findings highlight the significance of geographical regions and plant selection as contributing factors affecting nutritional qualities of wild sour plum fruit. The study revealed that wild sour plum is nutrient-dense and has nutritional content that are in line with the recommended daily intake of minerals such as calcium, copper, magnesium, phosphorus, vitamin E and zinc, and may significantly contribute to daily nutrient requirements in human nutrition. These findings accelerate the efforts for one of the United Nations' Sustainable Development Goals (SDG), 'Zero Hunger', which entails that every everyone must enjoy their right to nutritious food while sustaining the environment. Based on the nutritional data presented in this study, wild sour plum fruit, which is mostly consumed by rural communities in Southern Africa, but still underutilised, have the potential to combat malnutrition and certain nutrient deficits. Therefore, selecting plants with the same nutritional value would be a relatively quick process because there is a lack of baseline information on the desired germplasm to accelerate the breeding of the highly nutritious crop. In addition, the successful breeding programmes of wild sour plum will accelerate the commercialization of the wild sour plum which can be consumed as raw or processed to value-added products such as jam, Juice, oil, and baked goods. Therefore, findings of this study will help plant breeders choose accessions with high nutritional content, which are directly influenced by regional climatic conditions.

Authors contributions BL was involved in study design, data collection and write-up. MKM was involved in data analysis, interpretation and write-up. Rebogile Mphahlele was involved in data interpretation and analysis.

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Availability of data and materials Data generated for this study is available from the corresponding author on formal request.

Declarations

Ethics approval and consent to participate Authors declare that they have no conflicts of interest.

Informed consent Not applicable.

Competing interests The authors have not disclosed any competing interests.

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