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Plant-based traditional foods and beverages of Ramotswa Village, Botswana

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Abstract

Background and objectives: Different communities have various types of edible plants at their nearby ecology from which they process their traditional foods that make the basis of diversified diets for food and nutrition security. Exploration of various ethnic traditional foods knowledge will have an immense contribution for preservation and sustainability of the traditional food system and culture. The objectives of this research were to investigate and document the edible plant type used and description on the processing of plant-based traditional foods/dishes and beverages of the Ramotswa village, Botswana. Majority of the Ramotswa village residents belong to the Balete tribe.

Methodology: Questionnaire interviews and focus group discussions (FGD) were used in the documentations of edible plants type, methods involved in the processing, values, challenges, and the seasonal availability.

Results and discussion: There are 50 wild edible plants used and most are available during rainy season. Maize, sorghum, beans, cooking melon, watermelon, and pumpkin are widely used domesticated crops. The edible part of wild plants is utilized in different ways. Some consumed after minor processing and some as cooked, boiled, recipe in traditional dishes, inoculum in fermentation, substrate in traditional beverages, and medicinal plants. Food safety concerns were indicated for few products. High temperature and shortage of rainfall are making some edible plants scarce. For some, preparation takes a long time; and when processing is not properly done, unpleasant odor, bitter taste, and mold growth can result, particularly for traditional beverages. Even though, most traditional foods/dishes and beverages are still consumed and enjoyed by the communities, there are worries that the young generation has limited knowledge and skills to process and utilize them.

Conclusions: Most plant-based traditional foods/dishes consumed are low in sugar and fat, but are wholesome (whole grains, with dietary fibers) with high potential for diet diversification. The documentation provided will help to create awareness for preservation of the traditional foods/dishes and beverage culture, and as a baseline information for further studies for those nutrient and bioactive compound data are not available.

Keywords: Botswana, Bogobe Jwa Ting/Lekatane, Bojalwa Jwa Setswana/Ila, Dikgobe, Khadi, Lekatane, Lechotlho, Lengangale, Morogo Wa Dinawa, Mosukujwane tea, Ramotswa, Wild edible plants

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Introduction

Traditional/indigenous food product(s) are that a given community acquire and process from bio-diverse plant and animal sources available in their ecology in which knowledge and skills are preserved and transmitted by oral or other folklore means. Traditional foods have special place among the communities because of their unique sensory acceptability, cultural heritage, health benefits, religious, and commercial values. For example, the Mediterranean traditional food patterns [1] are highly recognized as healthful because they are associated with the reduction of all causes of mortality [2] and are high in anti-oxidants [2, 3].

The Lancet Commissions review on sustainable food systems [4] recommended to move toward healthy diets derived from whole grains, nuts, fruits, vegetables, and legumes, a low to moderate amount of seafood and poultry, low or no inclusion of red meat, processed meat, added sugar, refined grains, and starchy vegetables to achieve a win-win situation (i.e., sustainable-healthy diets and environment). A review [5] on the documentation of indigenous foods in 11 different countries from 2001 showed that the sustainability of indigenous foods are globally threatened, by factors like an intensive cultivation of limited crops, various anthropogenic activities, urban land policy, and life style changes.

Indigenous food system revival has been given due attention by FAO [6] high-level experts because they are cornerstone for sustainable diets of low environmental impacts [7]. There are more than 14,000 edible plant species globally of which only 150 to 200 species are used from which 60% of human calories are derived from rice, maize, and wheat [4]. Agro-industrial food system that depends on limited crops has been recognized to cause biodiversity loss, environmental pollution, land degradation, and malnutrition [4, 7, 8].

A study conducted [9] in Gaborone on cardiovascular disease risk factors reported that a relatively high prevalence of overweight, obesity, and low intake of high-density lipoprotein (HDL) cholesterol in young adults with a shifting of diets toward high in sugar, refined starches, and meat. Traditional/indigenous food (TIF) consumption in two urban and two rural areas of Botswana were found important for household food security and dietary diversity, even though TIF consumption was declining due to preference for modern foods [10, 11].

In Botswana cuisine, plant-based ingredients used are either harvested from the wild or grown in home gardens and fields of which wild plant contribution are known to be significant [12]. However, information on the types of wild plants and the description on processing of plant-based traditional foods/dishes and beverages used by various ethnic groups within different villages of Botswana are limited. To create awareness on the

sustainability of traditional foods of a given community, documentation of traditional food system is important. Such information is used for preservation of traditional food heritage, bio-piracy, biodiversity conservation, unnecessary eradication (clearing), entrepreneurship development, chemical investigation, standard development, wild species domestication, education material to teach in schools, tourism, and food trade fairs. In view of this, in this paper, plant-based foods/dishes and beverages of Ramotswa Village of which majority of the village residents are Balete tribe are reported.

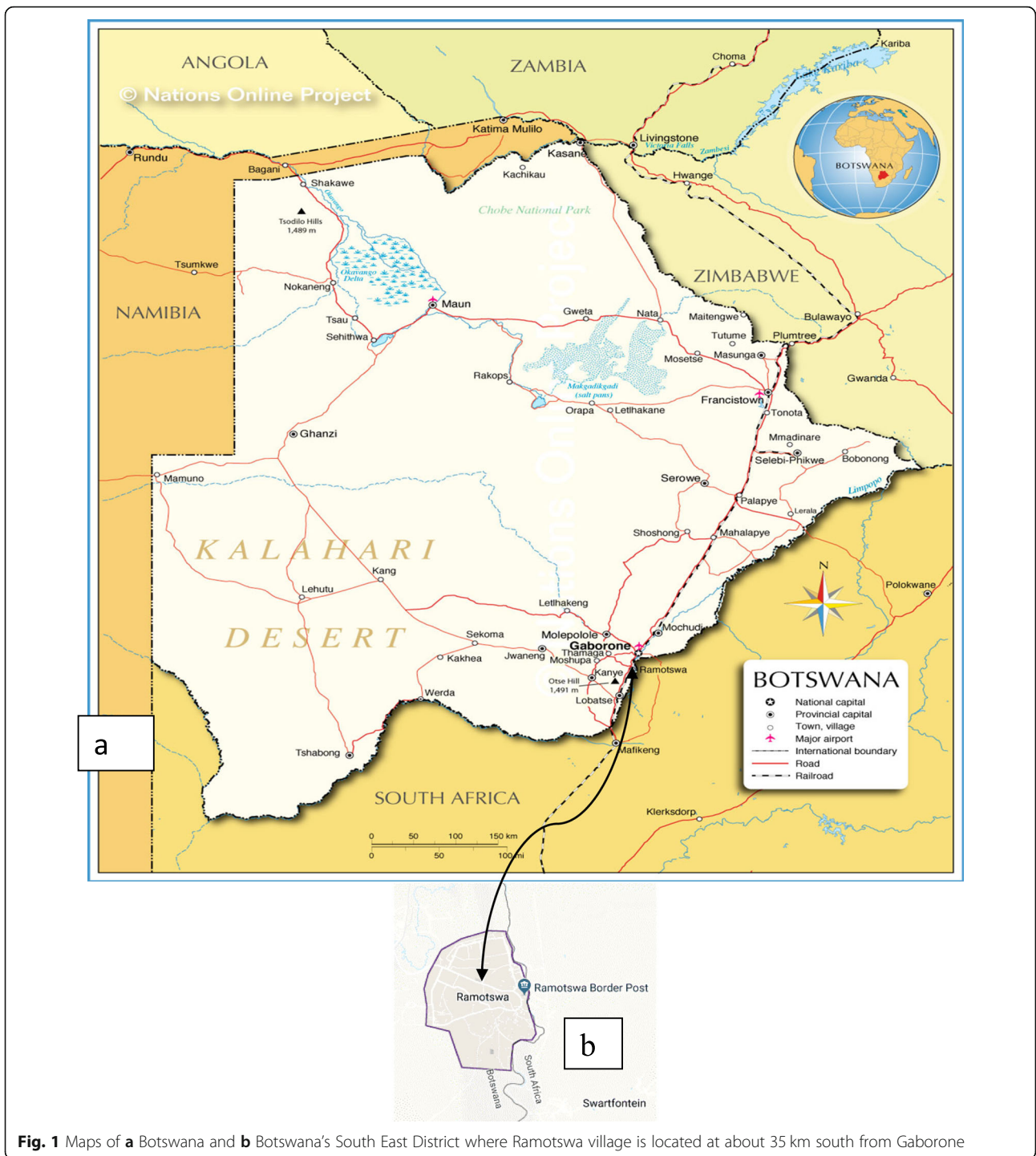
Methodology

The study was conducted at Ramotswa village (25°13' S and 25°40' E, South-East District, 35 km from Gaborone) (Fig. 1a, b). The majority of the village residents belong to the Balete tribe. A qualitative research approach was followed [13, 14].

A structured questionnaire for face to face interview and questions for FGD were developed through several consultative meetings with a team of scientists (food scientists, sociologist, and botanist). Questions included were edible plants type used, processing, food value, health/medicinal claims, safety and taboos, preservation methods, seasonal availability, challenges, and status on knowledge and culture of indigenous foods. The term "traditional food" and "traditional dish" were defined as those "without recipes" and "with different recipes," respectively. Questionnaire pre-testing was conducted at Bokaa village (24°25'35" S and 26°1'0" E, Kgatleng District, 37 km northeast of Gaborone).

The Paramount Chief and deputy Chiefs of the Ramotswa village were consulted. They consented to the research objective and FGD schedule and assisted on selection of FGD participants. The criteria used were residents in the village, have full knowledge and skills on traditional foods/dishes and beverages of the village, processing for family consumption and/or for sell, past experience and ability to judge current scenario, knowledge in the culture and language of the communities, both male and female participation, and age between 40 and 87 years. The FGD was conducted involving 14 participants by an experienced sociologist. When consensus on a particular issue was reached among FGD participants, information generated was captured on flip chart by the facilitator and two rapporteurs on note books. An audio decoder was also used.

The interviews were conducted by trained enumerator, a resident of Ramotswa village. Vernacular language and wherever possible English language were used, and the scientific names on the list of edible plants were generated by a Botanist Dr. Shimane Makhabu at BUAN, Botswana. The data from 25 questionnaires were



decoded in a spreadsheet of Microsoft Excel, 2013, and responses were extracted and reconciled information with FGD are reported.

Results and discussions

The participant demographic characteristics are shown in Table 1. All participants were from Balete tribe,

Christians. Majority of them were subsistence farmers and household food processors.

Wild food plants

There are 50 wild edible plants used in the study area (Table 2). For most fruits/pulp, in some cases like morula (*Scleroccaria birrea*), the seeds/nuts are also used. For motlopi (*Boscia albitrunca*) and mogakangwaga

Table 1 Demographic characteristics of participants from Ramotswa village, Botswana

Demography		Interview	FGD
Gender	Male	13	10
	Female	12	4
Age (years)	21–30	6	0
	31–40	8	0
	41–50	2	0
	51–60	0	1
	61–70	5	5
	> 70	4	8
Education	Cannot read or write	5	4
	Primary education	4	6
	Secondary education	5	1
	Certificate	2	1
	Diploma	5	0
	Bachelor's degree	4	1
Occupation	Postgraduate degree	0	1
	Subsistence farmer/house hold food processor	11	4
	Kgosana (deputy chief)	0	9
	Large scale food processor	2	0
	Mechanics	1	0
	Internship	3	0
	Unemployed	3	1
	Teacher	1	0
	Human resource	1	0
	Policeman	1	0
	Carpenter	1	0
	Graduate	1	0

(*Trochomeria debilis*), fruits and roots/tubers of the same plant are used. Some are used as leafy vegetables (Table 2). For mokgalo (*Ziziphus mucronata*), its fruit pulp, leaves, roots, bark, and seeds are used. Mokgalo seeds are ground and eaten as powder, and leaves' paste is used to heal wounds, sores, and boils, while its roots are boiled and the juice is used to relief pain. Fruits of morula and moretlwa (*Grewia flava*) are used in the traditional beverages. Some leaves such as mosukujane (*Lippia scaberrima*), kgomodimetsing (*Myrothamnus flabellifolius*), lengana (*Artemisia afra*), seswagadi (*Jatropha zeyheri*), rammola, and moritelatshwene are used for tea-like beverages. The fruits of motlopi are used in the traditional beverages, and its roots for making a coffee type beverage. Fruit pulp of mmupudu (*Mimops zeyheri*) can be compacted and dried for preservation. Mogwana (*Grewia bicolor*) fruits are used to flavor traditional beverage khadi. Khusubele (*Withania spomnifera*) is used as a relish. Water is extracted from

the roots of leruswa (*Stomatostemma monteiroae*). The fruits of morobe (*Ehretia sp.*) were indicated to cause constipation if consumed in large amounts. No taboo indicated for wild edible plants. Availability of most wild edible plants is limited after rains. Most of them were described as perishable, whereas few as semi-perishable and durable (Table 2). The study indicates that with availability of water, there is domestication potential. However, to make them available during off rainy season, development of appropriate food preservation technologies are required. For some wild edible plants, market potential was high and very high, however, for majority was poor (Table 2).

Wild plants for foods and medicinal use

The economic value, potential for food and nutrition security of Botswana edible wild plants [15–17], wild vegetables [18], and medicinal importance [19] for some indicated in this paper were described. Morula

Table 2 List (names) of wild edible plants used in indigenous foods, dishes, and beverages of Ramotswa village along with parts and forms used, value, food safety, taboos, market potential, seasonal availability, and perishable nature of the edible plants

No	Ver. N.	Eng. N	Sci. N	Parts U.	Forms U.	Value/use K.	Food Saf. C.	Taboo P.	Month. A. (Perish. N.)
1	Dikgogo		<i>Unidentified</i>	Fruits	IF – can be consumed raw or cooked	-	-	N/A	After rains (Pe)
2	Khusubele/wild tomato	Wild goose berry	<i>Withania spornifera</i>	Fruits	IF – an ingredient in relish	-	-	N/A	After rains (Pe)
3	Legabala	Wild cucumber	<i>Coccinia sessilifolia</i>	Fruits	IF – can be cooked/boiled	-	-	N/A	After rains (Pe)
4	Leroplane		<i>Unidentified</i>	Fruits and Leaves	IF & ID – green leafy vegetable	-	-	N/A	After rains (Pe)
5	Mabowa	Wild mushrooms	<i>Agaricus sp</i>	Whole fruiting body	IF – can be consumed raw or cooked	NP – carbohydrate, protein and fiber	-	N/A	After rains (Pe)
6	Mogabaditswane	Trochomeria	<i>Trochomeria debilis</i>	Fruits	IF - fruits consumed directly	-	-	N/A	After rains (Pe)
7	Mogakangwaga	Trochomeria	<i>Trochomeria debilis</i> (Sond.) Hook.f.	Fruits, tubers & (Mogabaditshwane)	IB(FR) – tuber IF – fruits	-	-	N/A	After rains (Pe)
8	Mogodiri	Common taibos/ fire-thorned rhus	<i>Rhus pyroides</i> Burch	Fruits	IF	-	-	N/A	After rains (Pe)
9	Mogorogorwana/Moruta	Corky-bark monkey orange	<i>Strychnos cocculoides</i> Baker	Fruits	IF – Juicy pulpy fruit	NP- vitamins and minerals	-	N/A	After rains (Pe)
10	Mogwana	False brandy bush	<i>Grewia bicolor</i> Juss.	Fruits	IF & IB(FR) – used to boost flavor in mogakangwaga alcoholic beverage (Khadi)	NP – Vitamins and minerals	-	N/A	After rains (Pe)
11	Mokate	Wild Melon	<i>Citrullus lanatus</i>	Fruits	IF – cooked before consumption.	-	-	N/A	After rains (Pe)
12	Mokgalo	Buffalo Thorn	<i>Ziziphus mucronata</i> Willd.	Fruits pulp, leaf, root, bark & seed	IF – Seeds ground and eaten as powder (Sekome)	MD – pastes of leaves and used to heal wounds, boils or sores. Roots are boiled and the juice is used to kill pain	-	N/A	After rains (Du)
13	Mokgomphatha	Rough leaved raisin bush	<i>Grewia retinervis</i> Burret	Fruits	IF	-	-	N/A	After rains (Pe)
14	Mmilo	Wild media	<i>Vangueria infausta</i> Burch.	Fruits pulp	IF	NP – carbohydrate, vitamins and minerals	-	N/A	October – January (Pe)
15	Mmilofatshe		<i>Unidentified</i>	Fruits	IF	-	-	N/A	After rains

Table 2 List (names) of wild edible plants used in indigenous foods, dishes, and beverages of Ramotswa village along with parts and forms used, value, food safety, taboos, market potential, seasonal availability, and perishable nature of the edible plants (Continued)

No	Ver. N.	Eng. N	Sci. N	Parts U.	Forms U.	Value/use K.	Food Saf. C.	Taboo P.	Month. A. (Perish. N.) (Pe)
16	Mmupudu/ Mompudu	Common red milkwood	<i>Mimops zeyheri</i> Sonder.	Fruits pulp	IF - can be compacted and dried to preserve	-	-	N/A	October – January (Pe)
17	Moe		<i>Berchemia zeyheri</i>	Fruits	IF	-	-	N/A	October – January (Pe)
18	Mopenoeng/ Molalagaka	Jacket plum	<i>Pappea capensis</i> Ecklon & Zeyher	Fruits	IF	-	-	N/A	After rains (Pe)
19	Moojane		Unidentified	Fruits	IF	-	-	N/A	After rains (Pe)
20	Moretwa	Wild berry	<i>Grewia flava</i> DC.	Fruits pulp	IF- berries are readily consumed IB (FR) – can be fermented to make a drink.	NP – carbohydrate, vitamins and minerals	-	N/A	October – January (Pe)
21	Moretologa wa kgomo/ Morotologagomo	Large sourplum	<i>Ximenia caffra</i> Sonder	Fruits pulp	IF	-	-	N/A	October – January (Pe)
	Moretologa wa pudu/ Morotologapudi	Small sourplum	<i>Ximenia Americana</i> L.						
22	Morobe		<i>Ehretia rigida</i> (thumb.) Druce	Fruits	IF	-	Causes constipation if consumed in large amounts	N/A	After rains (Pe)
23	Morula	Marula	<i>Sclerocaria birrea</i> (A. Rich.) Hochst.	Fruits pulp, nuts	IF IB (FR)	NP – carbohydrate, vitamins, minerals, fats and antioxidants	-	N/A	October – January (Pe)
24	Mothatswa	Milk plum	<i>Englerophytum magalismontanum</i>	Fruits	IF	-	-	N/A	October – January (Pe)
25	Phare		Unidentified	Fruits	IF	-	-	N/A	After rains (Pe)
26	Ntoroko	Prickly pear	<i>Opuntia sp</i>	Fruits	IF	-	-	N/A	After rains (Pe)
27	Sekgalofatshe		Unidentified	Fruits	IF	-	-	N/A	After rains (Pe)
28	Sereledi	Common kalanchoe	<i>Kalanchoe rotundifolia</i>	Fruits	IF	-	-	N/A	After rains (Pe)
29	Motlopi/Motopi	Shepherd's tree	<i>Boscia albitrunca</i> (Burch.) Gilg & Benedict	Fruits & roots	IF – fruits can be consumed raw IB (NF) – outer cover of roots are washed,	MD – used to boost libido	-	N/A	After rains (Pe)

Table 2 List (names) of wild edible plants used in indigenous foods, dishes, and beverages of Ramotswa village along with parts and forms used, value, food safety, taboos, market potential, seasonal availability, and perishable nature of the edible plants (Continued)

No	Ver. N.	Eng. N	Sci. N	Parts U.	Forms U.	Value/use K.	Food Saf. C.	Taboo P.	Market P.	Month. A. (Perish. N.)
30	Mokgwara/ Mothatswamano	Cat's tail	<i>Hembsstaedia odorata</i>	Roots	chopped, roasted and ground to make coffee. IF – roots chewed and spat like sweet reed, can also be boiled to drink	-	-	N/A	P	After rains (Pe)
31	Ntige		<i>Indigofera bainesii</i> Baker	Roots	IF- consumed like sweet reed	-	-	N/A	P	After rains (Pe)
32	Tlodi		Unidentified	Roots	IF	-	-	N/A	P	After rains (Pe)
33	Tshuge		<i>Chlorophytum sphacelatum</i> subsp. <i>Sphacelatum</i> (Baker) Kativu	Roots	IF – roots peeled and roasted	-	-	N/A	P	After rains (Pe)
34	Bokwidi	Wild onion	<i>Ornithogalum tenuifolium</i>	Tubers	IF	-	-	N/A	P	After rains (Pe)
35	Diphoni		Unidentified	Tubers	IF – boiled or roasted	-	-	N/A	P	After rains (Pe)
36	Leruswa	Monteiro vine	<i>Stomatostemma monteiroae</i>	Tubers	IB (NF) – water is extracted from the tuber.	-	-	N/A	P	After rains (Pe)
37	Radikgane	Morning glory	<i>Ipomea bolasiana</i>	Tubers	IF	-	-	N/A	P	After rains (Pe)
38	Serowa		Unidentified	Tubers	IF	-	-	N/A	P	After rains (Pe)
39	Thoma		Unidentified	Tubers	IF – tuber is consumed raw and has a pungent aroma	-	-	N/A	P	After rains (Pe)
40	Mosukujane	Lemon bush	<i>Lippia scaberrima</i>	Leaves	IB(NF) – leaves can be boiled and taken as tea or added to instant tea	MD – the tea can relief chest pains and treat colds	-	N/A	VH	After rains (Sp)
41	Kgomodimetsing	Resurrection plant	<i>Myrothamnus flabellifolius</i> Welw	Leaves	IB (NF) – tea plant	NP – rich in antioxidants and is herbal	-	N/A	H	After rains (Pe)
42	Lengana		<i>Artemisia afra</i>	Leaves and roots	IB(NF) – tea plant	MD – treats asthma and colds	-	N/A	VH	After rains (Pe)
43	Leshwe/Leswe?		<i>Ceropegia rendalii?</i>	Leaves	IF & ID - green leafy vegetable	-	-	N/A	P	After rains (Pe)

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No	Ver. N.	Eng. N	Sci. N	Parts U.	Forms U.	Value/use K.	Food Saf. C.	Taboo P.	Market P.	Month. A. (Perish. N.)
44	Moritlatshwene		Unidentified	Leaves	IB(NF) – tea plant	MD	-	N/A	P	After rains (Sp)
45	Mothukhwi		Unidentified	Leaves	IF & ID – green leafy vegetable, bitter in taste	-	-	N/A	P	After rains (Pe)
46	Rammola		Unidentified	Leaves	IB(NF) – leaves make tea	MD – similar to mosukujane	-	N/A	P	After rains (Sp)
47	Rothwe	Spider whisp	<i>Cleome gynadra</i>	Leaves	IF & ID – green leafy vegetable, bitter in taste.	NP – vitamins, antioxidants, iron	-	N/A	H	After rains (Pe)
48	Seswagadi		<i>Jatropha zeyheri</i> Sond.	Leaves	IB(NF) – tea plant	NP – herbal	-	N/A	P	After rains (Pe)
49	Thebelefwane		Unidentified	Leaves	IF & ID – green leafy vegetable, bitter in taste	-	-	N/A	P	After rains (Pe)
50	Thepe		<i>Amaranthus sp</i>	Leaves, shoots, seed	IF – leaf or shoots are cooked and consumed	-	-	N/A	N/A	After rains

Ver. N. vernacular name, Eng. N English name, Sci. N scientific name, Parts U. parts/forms used, IF indigenous food, ID indigenous dish, IB indigenous beverages, FR fermented, Use K. use knowledge, NP nourishment potential, MD medicinal, N/A not available, Food Saf. C. food safety challenge, Market P. market potential, VH very high, H high and P poor, Month. A. months available, Perish. N. perishable nature, Du durable, Pe perishable, Sp semi-perishable

and mmilo (*Vangueria infausta*) were valuable sources of vitamin C, fibers, and minerals (K and Mg) [20]. Mokgalo roots were reported to have a strong antioxidant activity (IC_{50} , 2.5 mg/mL) [21], and the bark to treat some diseases [22]. Motlopi is eaten either raw or cooked and can be concentrated to make a syrup and porridge, and its unripe fruits are used to treat epilepsy [23]. Mmupudu has potential for production of jam, jelly, and dried products [24]; its roots are used to treat syphilis, stomach ache, and gynecological infections and leaves for diabetes mellitus management [25]; and flavonoids were indicated as major bioactive compounds [26]. *Ximения caffra* and mmupudu seed oils were reported to have anti-proliferative effect on

human colon adenocarcinoma (Caco-2), human embryonic kidney (HEK-293) cells [27], and women breast cancer cell lines [28]. Both seed oils were rich in oleic acid: 59.4% and 55.7%, respectively [27]. Lengana is one of the most commonly used herbal medicines in the southern African region because of its monoterpenoids and sesquiterpenes [29] and described as tea plant. Its leaves and roots were indicated to treat asthma and colds with very high demand.

Domesticated food plants

There are 13 domesticated edible plants used (Table 3). Sorghum, maize, and pearl millet are used in traditional foods/dishes; sorghum and maize in

Table 3 List (names) of domesticated edible plants used in indigenous foods, dishes, and beverages of Ramotswa village along with parts used, value, food safety, taboos, market potential, seasonal availability, and perishable nature

No	Ver. N.	Eng. N	Sci. N	Parts U.	Forms U.	Value/Use K.	Food Saf. C.	Taboo	Market P.	Month. A. (Perish. N.)
1	Mabele	Sorghum	<i>Sorghum bicolor</i> L.	Grains	IF, ID & IB(FR)	NP – fiber, carbohydrate, vitamins and N/minerals	-	N/A	VH	January – April (Du)
2	Mmidi	Maize	<i>Zea mays</i> L.	Grains	IF, ID & IB(FR)	NP – fiber, carbohydrate, vitamins and minerals	-	N/A	VH	January – April (Du)
3	Lebelebele	Pearl millet	<i>Pennisetum glaucum</i> (L.) R. Br.	Grains	IF, ID	-	-	N/A	P	January – April (Du)
4	Dinawa	Common beans	<i>Phaseolus vulgaris</i> L.	Pulses/seeds	IF, ID	NP – proteins, fiber, vitamins and minerals	-	N/A	VH	January – April (Du)
5	Ditloo	Jugo beans	<i>Vigna subterranean</i> (L.) Verdc	Pulse/seeds	IF, ID	NP – proteins, fiber, vitamins and minerals	-	N/A	H	January – April (Du)
6	Lethodi	Mung bean	<i>Vigna radiata</i> (L.) R. Wilczek	Pulse/seeds	IF, ID	NP – protein, vitamins and minerals	-	N/A	H	January – April (Du)
7	Manoko/ matonkomane	Groundnuts	<i>Arachis hypogaea</i> L.	Nuts	IF- nuts are readily consumed. Also cooked with other grains to complement protein source	NP – rich in protein and fats	-	N/A	VH	January – April (Du)
8	Sonobolomo	Sunflower	<i>Helianthus annus</i> L.	Grains	IF – Roasted and eaten as a snack	NP – high in oil. Also has some minerals	-	N/A	VH	January – April (Du)
9	Lephutshe	Pumpkin	<i>Cucurbita pepo</i> L.	Pulp	IF	NP – carbohydrate, vitamins, minerals and fiber	-	N/A	H	January – April (Sp)
10	Magapu	Watermelon	<i>Citrullus lanatus</i> (Thunb.) var. <i>lanatus</i>	Pulp & seeds	IF & IB(FR)	NP – carbohydrate, vitamins and minerals	-	N/A	VH	January – April (Pe)
11	Makgomane	Squash		Fruit	IF	NP – vitamins and minerals	-	N/A	H	January – April (Du)
12	Marotse/ makatane/ maowane	Melon	<i>Citrullus lanatus</i> var. <i>citroides</i> (L. H. Bailey) Mansf.	Pulp, seeds, rind	IF, ID	NP – rich in vitamins and antioxidants	-	N/A	VH	January – April (Pe)
13	Ntshê	Sweet reed (sweet sorghum)	<i>Sorghum bicolor</i> (L.) Moench	Stem reed	IF	NP – sugars, carbohydrates, fiber	-	N/A	VH	January – April (Pe)

Ver. N. vernacular name, Eng. N English name, Sci. N scientific name, Parts U. parts/forms used, IF indigenous food, ID indigenous dish, IB indigenous beverages, FR fermented, Use K. use knowledge, NP nourishment potential, Food Saf. C. food safety challenge, N/A not available, VH very high, H high and P poor, Month. A. months available, Perish. N. perishable nature, Du durable, Pe perishable, Sp semi-perishable

fermented beverages. Among pulses, common beans, Jugo beans and Mung beans, are consumed in traditional foods/dishes. Ground nuts are consumed as snacks, oil sources, or cooked with other recipes. Sunflower is consumed as a roasted whole snack. Watermelon (*Citrullus lanatus* (Thunb.) var. *lanatus*) pulp and seeds are consumed in traditional foods. The melon (*Citrullus lanatus* var. *citroides* (L. H. Bailey) Mansf.) pulp, rind, and seed are consumed in the traditional foods and dishes. Pumpkin pulp and makgomane (squash like) fruits are used in traditional foods. The edible plant parts are used as sources of fiber, carbohydrates, vitamins, and minerals. Some also indicated to have health-promoting properties probably because of their anti-oxidant potential. No taboos on the domesticated plants were reported. The market potential for most domesticated edible plants were very high and high, but pearl millet was indicated poor (Table 3). The market potential for pearl millet is probably low due to its high-fat content prone to rancidity.

Indigenous foods

Borekhu (gums from trees and bushes of genera *Vachellia* and *Senegalia*)

Borekhu is consumed as a snack right there after harvest extract, especially from *Vachellia tortilis*. The extract is

also found in mogonono (*Terminalia sericea*). The product is available from September to November.

Bogobe Jwa Ting (fermented sorghum porridge)

Cleaned sorghum grains milled into flour or decorticated sorghum grain flour is mixed with warm water (1:2, w/v) and left to ferment for 2 days. To speed-up fermentation, potatoes are cut and added into the mixture. Potatoes supply starch and sugar as substrate and may also contribute to fermenting microorganisms, in which case fermentation only takes 1 day. The fermented paste is called “ting.” The fermented paste is cooked to porridge in a boiling water for about 15 min while whisking to avoid lumps. The product is usually consumed with sugar, milk, madila (sour milk) or other relishes, and supply fiber and proteins. It may cause heart burn to some individuals. Ting is available throughout the year.

Mosokwane (unfermented sorghum porridge)

The cooking method for mosokwane is similar to that for ting, and it can be consumed with milk, madila, soup, meat, or other relishes.

Ditloo (Jugo beans) and Letlhodi (mung bean)

Both beans are cooked, salt, and edible oil may be added for taste. The product is said to supply proteins, fiber, and carbohydrates and is available from January to June.



Fig. 2 **a** Lechotlho (maize mealies-fresh maize grains at around physiological maturity is cooked with its sheath while on its cob and then dried), ingredient for processing of Dikgobe. **b** Samp (Setampa-decorticated and cracked maize grains), ingredient for processing of Dikgobe. **c** Blackeye cowpeas, pulse ingredient for processing of Dikgobe. **d** Bambara ground nut, pulse ingredient for processing of Dikgobe. **e** Dikgobe tsa lechotlho (blackeye cowpea and lechotlho-cooked). **f** Dikgobe tsa setampa (decorticated maize and Bambara ground nut-cooked)

Lechotlho (Letshotlho, Mpsapsa)

Lechotlho is processed by cooking physiologically ripe maize grains in water with its sheath on its cobs (Fig. 2a). The cooked maize is cooled, sun dried, and stored until needed. Lechotlho is a parboiled maize and is whole grain. Besides, being whole grain, it is possible that bio-active compounds can also diffuse into the cooked grain from the maize sheath while cooking as for parboiled rice. The dried product can be stored for 2 to 3 months. After re-cooking, lechotlho is eaten as snack or cooked with beans to make dikgobe (Fig. 2d). Lechotlho may cause constipation if taken in large amounts and is available from April to May.

Lebutho (cooked maize)

Ripe whole maize grains on its cob without sheath is cooked, and the grain is removed from its cob and dried. The dried grain can be stored for about 12 months. After re-cooking, lebutho is eaten as snack or cooked with beans to make dikgobe. Lebutho provides energy and may cause constipation in some individuals and is available from December to May.

Lengangale

Lengangale is processed from lerotse/lekatane (Fig. 3a) rind. Melon rind is sliced into stripes and sun dried for about 3 days. If not properly dried, it can develop mold. Dried lerotse (lengangale) can be stored at room temperature for about 1 year. Lengangale is cooked and served and is available from January to June.

Lekatane/makatane/marotse

Lekatane (melon, an orange-fleshed type of melon used for cooking only) is cooked in water for 30 min, and salt may be added for taste and can be served with milk or sour milk (kgodu ya lerotse/lekatane) (Fig. 3b). Lekatane is said rich in calcium and helps to develop strong bones, supplies fiber, and may cause bloating. Lekatane is available from March to May.

Lekgomane/makgomane/maraka

Makgomane (whole with its seed) is cut in half and washed and cooked for about 30 min. Salt may be added for taste and then can be served plain or with milk. Lekgomane is reported to give energy, fiber, and calcium and to prevent constipation. Lekgomane may cause uneasiness (bloating) in some individuals and is available from March to May.

Leswabi (dried sweet reed, ntšhê)

Ntšhê stalk is harvested, outer green layer peeled off, and sun dried for 2 to 3 days and consumed as snack. Leswabi gives energy, because of its sugar, but can cause tooth decay. Leswabi is stored in a cool dry place for 6 months and is available from March to May.

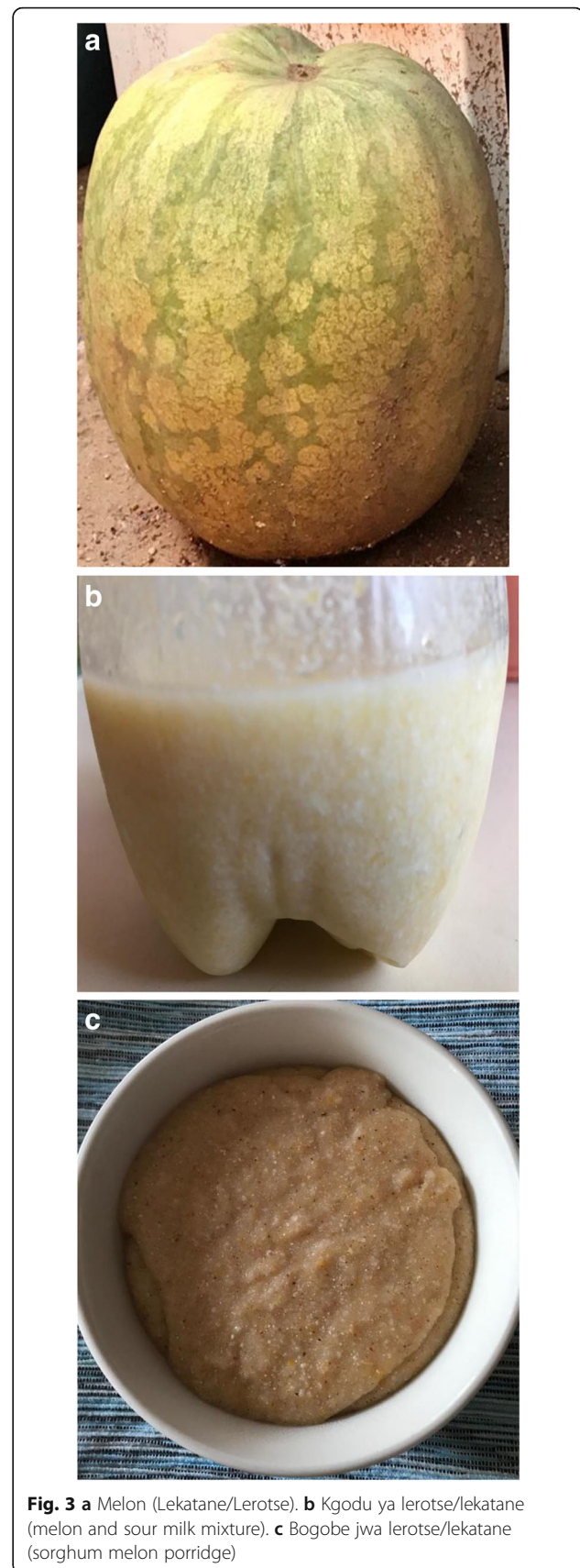


Fig. 3 a Melon (Lekatane/Lerotse). b Kgodu ya lerotse/lekatane (melon and sour milk mixture). c Bogobe jwa lerotse/lekatane (sorghum melon porridge)

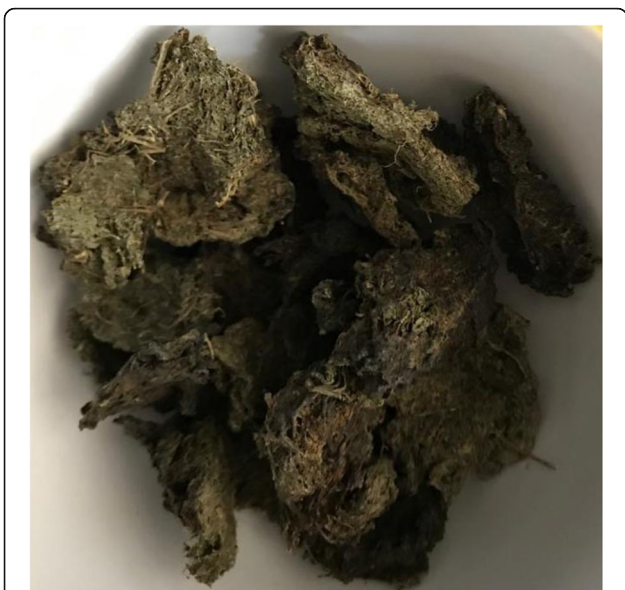


Fig. 4 Morogo wa dinawa (cooked and dried bean/cowpea leaves)

Morogo Wa Dinawa (cooked and dried pulse leaves)

The cowpea leaves are cooked in water for 1 to 2 h and pounded until become soft. After then are spread in an open sack to sun dry. The dried product can be stored for about 1 year (Fig. 4). To prepare, morogo wa dinawa, the dried leaves are re-constituted in water, drained, and then cooked. Salt, onion, tomato, and edible oil may be added. The product is high in fiber and is indicated may cause diarrhea and heart burn in some individuals. The product is available from April to June.

Indigenous dishes

Bogobe Jwa Lekatane/lerotse (melon porridge) (typical example Fig. 3c)

There are three methods of processing from sorghum and melon.

Kgodu preparation method	Sorghum flour/paste
a. Melon is washed and sliced, and seeds and rinds are removed; cooked and fermented to make Kgodu	Unfermented sorghum flour
b. Melon is washed and sliced, and seeds and rinds are removed; cooked to make Kgodu	Fermented sorghum paste
c. Melon is washed and sliced, and seeds and rinds are removed; cooked to make Kgodu (sour milk may be added)	Unfermented sorghum flour and sour milk can be also added during cooking

Method a: The pulp is cooked until smooth and cooled, and milk is added. The mixture is stored in an airtight container to ferment. The product is called “kgodu” and is refrigerated until needed. Kgodu is boiled

and sorghum flour is added to make a thin or thick porridge. Method b: the melon pulp is cooked until smooth to make “kgodu” to which ting (fermented sorghum paste) is added and further cooked for about 30 min into thin or thick porridge. Method c: the melon pulp is cooked until smooth to make “kgodu” to which sorghum flour is added to make thin or thick porridge. The sour milk may be mixed with kgodu or added during porridge cooking. The porridge is cooked for about 30 min. The product is reported to be rich in vitamins and proteins and is available from March to April when melons are in season.

Dikgobe

Dikgobe formulation

Name	Maize grain	Legumes (beans or peas)
Dikgobe tsa lechotlho (Fig. 2e)	Lechotlho	Letlhodi, cowpea (Fig. 2c) or Bambara ground nut
Dikgobe tsa lebutlho	Lebutlho	Letlhodi, cowpea, or Bambara ground nut (Fig. 2d).
Dikgobe tsa mmidi	Dried whole grain maize	Letlhodi, cowpea, or Bambara ground nut
Dikgobe tsa satampa (samp) (Fig. 2f)	Samp	Sugar beans, butter beans, cowpeas

For dikgobe made with lechotlho or lebutlho, both are required to be soaked for 30 min to an hour followed by cooking about an hour before adding pre-soaked legumes. Lechotlho and lebutlho are hard to cook because they are par-boiled dried whole maize grains. Mmidi (maize grain) is cooked for a shorter time than lechotlho and lebutlho because it is not par-boiled, and cooking time for dikgobe made with samp (Fig. 2b) is even shorter because maize is decorticated and cracked. Dikgobe is cooked until tender, and salt and edible oil can be added for taste. Dikgobe supply more nutrients like proteins, since it is a combination of beans and maize. Dikgobe tsa lechotlho is reported to cause constipation in some individuals. Dikgobe tsa satampa is said to cause heart burn and may also result in constipation and bloating in some individuals. Dikgobe is available throughout the year.

Leowane

Lengangale is cooked as described above and is mixed with pounded watermelon/melon seeds, cooked, and then served. Leowane is rich in oil from the seed and said it provide vitamins. Leowane is reported to cause nausea in some people and is available from March to May, also some indicated throughout the year.

Morogo wa dinawa le makgomane (bean leaves + makgomane)

Makgomane and bean leaves are washed, when beans leaves are half cooked, makgomane is added. Optional to makgomane, fruits like khusubele and melon can be also used. The mixture is mixed with vegetables, and salt is added for taste and cooked for a while until a mushy consistency is achieved. The product is served with a starch source after cooling or it can be sun dried for storage.

Indigenous beverages

Mosukujwane tea

Mosukujwane (*Lippia javanica* and *Lippia scaberrima*) leaves are harvested, air/sun dried for a day, boiled in a water for tea making, and sugar is added. The tea can be consumed with milk. Mosukujwane tea is said to heal the kidneys and is available from April to June.

Bojalwa Jwa Setswana (traditional sorghum beer)

Sorghum grain is cleaned and soaked in water for some minutes, water is decanted. The soaked grain is placed in a cool place for about 3 days for germination. The germinated grain is sun dried for about 2 days and milled to a make “momela” (malt). Cleaned ungerminated sorghum grain is milled to a flour and cooked in boiling water to make masokwane (adjunct) to a consistency of soft porridge (not thick), cooled, mixed with water, and put in a tank. Momela is then mixed with mosokwane and allowed to stay overnight in a tank to initiate fermentation. After fermentation, the mixture (masifa) is cooked (to gelatinize starches) for an hour and cooled to become “mogetlo.” The cooking is similar to mash cooking in modern brewing. The mixture (mogetlo) is cooled and allowed to stand overnight to ferment more. The semi-fermented sorghum (mogetlo) is cooked in water to further boost fermentable substrates. Additional water and momela is mixed with mogetlo, left for a day in tank covered with lid to allow further fermentation. After full fermentation, the product is sieved to separate the liquid from solid residue (moroko or dintshe or spent). The residue can be used to cook porridge. The beverage is reported to heal asthma, lowers high blood pressure and relieves the mind. The product is reported to cause diarrhea in some people and if too much fermentation happened to cause headache. The beverage is available throughout the year.

Bojalwa Jwa Ila

This is processed from germinated dried sorghum malt (momela), maize meal, and brown sugar; milk/madila may also be used. Addition of milk/madila may boost free amino nitrogen (FAN) requirements for yeast. Maize meal is cooked for about 30 min into soft

porridge, mixed with milk, and allowed to stay for 3 to 5 days. Then, momela is added and the mixture is cooked for about 2 h. After simmering, cooled and some momela and water are added, mixed, and allowed to ferment overnight; after then is ready. The beverage is available from January to March.

Khadi (fermented alcoholic beverage)

Khadi is processed from segwere (tuber) of “mogakangaga” (*Kedrostis hirtella*) plant and brown sugar. Segwere is sliced, washed, and mixed with cool water followed by addition of brown sugar. Mogwana fruits may be added as an inoculum, source of sugar, and flavor. The mixture is tightly closed in a container to ferment for about 2 days. When mogwana fruits are used, fermentation can take place only overnight. After fermentation, the mixture is sieved to remove segwere (what is left as spent) and the beverage is ready. The beverage is said to relieve the mind and gives energy. The product is not consumed by children and is available from November to January.

Morula beer

Fully ripe morula fruits are harvested, cleaned, washed, and cooked in a boiled water for easy release of juice/pulp and cooled. The outer cover is peeled off, and the fruits are beaten/pound softly (to avoid seed breakage) to release more juice/pulp. The juice pulp is sieved to remove the seeds, mixed well with water to make it less viscous, and placed in a closed container in a cool place to ferment for 1 to 2 days; after then is ready. The beverage is said to be rich in vitamins and relieve the mind and body. The product is said to cause heart burn to some individuals and is available from November to February.

Challenges indicated

Shortage of rain fall and high temperatures were indicted limiting the availability of some plant foods to be scarce (Table 4). The cooking time for some grains (beans and maize) was said long consuming energy, making them expensive. Some indicated infestation by pests such as weevils and molds when not dried properly. For some, the preparation takes a long time, particularly traditional fermented beverages. Fermentation defects also cause unpleasant odor and smell, bitter taste, and mold growth into the product.

Concerning the culture of traditional foods/dishes and beverages. Majority of the respondents 96% and 92%, respectively indicated that people in the village still eat traditional foods and drink traditional beverages. Also majority 88% and 92%, respectively indicated there is still knowledge on their traditional foods/dishes and beverage culture. However, few have indicated that there

Table 4 Challenges indicated concerning particular indigenous foods/dishes and beverages

Challenges	Indigenous foods/dishes and beverages																									
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U					
Shortage due to high temperature and poor rainfall		+	+	+				+		+	+		+	+	+		+				+			+	+	
Shortage of ingredients/expensive	+				+	+						+													+	
Not tasty as it used to be		+																								
Infestation by pests		+									+															
Infestation by pests such as weevils			+			+																			+	
Long-time to cook, shortage of fire wood, consume energy		+	+	+					+			+														
Infestation by mold			+										+				+									
Some people totally do not enjoy it									+																	
Takes long time to prepare/long process/too much work												+	+	+										+		+
Fermentation can be a problem in cool weather																									+	
Prolonged fermentation cause an unpleasant odor, smell and bitter taste, moldy																									+	

A Leowane, B Makgomane, C beans, D Kabu/maize, E Lechotlho, F Sorghum "mosokwane," G Leswabi, H Lengangale, I Lebutho, J Lethodi, K Leowane, L Dikgobe, M Morogo wa Dinawa, N Bogobe Jwa Lerotse, O Legodu, P Bogobe Jwa Ting, Q Khadi, R Traditional sorghum beer, S Morula beer, T Mosukujwane tea, U Bojwala Jwa Ila

is lack of information, too much ignorance of the new generation about traditional foods and beverages, and too much importation and preference for foreign foods and beverages as challenges. Beverages like khadi are not produced like before, so there is a limitation for new generation to learn about them.

Conclusions

The plant-based traditional foods/dishes and beverages of Ramotswa village, Botswana, were investigated. The study generated 50 wild edible plants. The diversity of wild edible plants used shed light on their high potential for diet diversification and for food and nutrition security. Most of the edible plants are whole grain/seed/nut, fruits, leaves, tuber/roots, and some are fermented. Such diets are in line with the Lancet Commissions review on sustainable food systems. However, the communities have worries that the young generation has limited knowledge and skills to acquire and process them. For those nutrient and bioactive compound data are not investigated, this study provides baseline information for further studies.

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Authors' contributions

GB led the research, drafted and edited the manuscript (MS) along with RKL. Photographs of foods/dishes were produced by RKL. NT conducted FGD. MM served as co-team leader and participated in FGD. GDH, ES, and SM edited the MS. SM provided the scientific names. All authors, contributed as member of the research team, read and approved the MS.

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Competing interests

The authors declare that they have no competing interests.

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