



Indigenous knowledge and marketing of edible wild fruits in Zimbabwe: A case study of Shurugwi, Gokwe south, Chirumhanzu, and Chivi districts

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ABSTRACT

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This study examines Zimbabwe's indigenous knowledge and marketing of edible wild fruits. Edible wild fruits contribute significantly to rural communities' nutrition in Zimbabwe. Recent research has shown that the indigenous fruits are now sold at markets and contribute to household income. A cross-sectional study was conducted in four districts of Shurugwi, Gokwe South, Chirumhanzu, and Chivi, in Zimbabwe, to investigate the role of traditional beliefs on marketing practices of edible indigenous fruits. A semi-structured questionnaire, which covered the demographic characteristics of respondents, type of fruits, preservation or processing methods, marketing channels, pricing, and uses of the fruits and income, was used. Interviews took place with 150 respondents in total. Most (51.4%) of the respondents were in the age group 35-54 years of age, and were mostly females. Although their main source of income was farming (48.7%), a reasonable income (10%) was obtained from trading, including selling edible wild fruits. The four districts reported a total of 42 edible indigenous fruits. The most common fruits were *Uuapacakirkiana*, *Vitexpayos*, *Azanzagarckeana*, *Ximenia. caffra*, *Strychnosspinosa*, *Diospyrosmespiliformis*, *Vangueriafausta*, *Grewiaflavescens*, and *Adansoniadigitata*. Respondents indicated that they consumed the fruits for nutritional (71.3%) and medicinal (42%) purposes. Drying, juicing, and fermentation were reported as the most common methods of processing indigenous fruits at household level. The study showed that there is potential for indigenous edible wild fruits to contribute to nutrition and household income. The marketing of the fruits needs to be regulated across the value chain.

Contribution/Originality: This study presents, for the first time, a discussion on the value chain of indigenous edible wild fruits from Zimbabwe, focusing on the potential for marketing and contribution to household income and nutrition. The study highlights the role of indigenous knowledge in the conservation of fruits.

1. INTRODUCTION

Li et al. (2016) define wild fruits as the underutilized or lesser-known native, indigenous, and exotic fruits of wild plants. Indigenous fruits refer to fruits locally produced, socially and culturally accepted as local foods (Cogill, 2015). They normally grow naturally in the wild as well as in the fields and near homesteads. We will use the term

indigenous and wild fruits interchangeably in this paper. Edible wild fruits offer various benefits to people's health and livelihoods in resource-poor communities (Bvenura & Sivakumar, 2017; Cheikhoussef & Embashu, 2013; Jamnadass et al., 2011; Shai, Ncama, Ndhlovu, Struwig, & Aremu, 2020). In Zimbabwe, indigenous fruits are used by marginalized groups as a supplementary source of food and income. However, their full economic value is yet to be explored (Maroyi & Cheikhoussef, 2017).

The emergence of rare diseases and rise in chronic illnesses among the populations due to high sugar, oil, and other chemicals in refined foods, have prompted the world to shift back to consumption of traditional foods (Joseph & Turner, 2020). High incidences of chronic diseases such as type 2 diabetes and obesity have magnified the negative effects of fast and refined foods. The growing interest in traditional foods is premised on the understanding that they are rich in fiber, minerals, and phytochemicals (Popkin, Adair, & Ng, 2012).

In Southern Africa, there is a growing demand for local foods such as sorghum, millet, indigenous fruits, herbs, and vegetables. Indigenous fruit trees (IFTs) are part of the non-timber food products (NTFPs) that include vegetables, medicinal plants, grasses, game, tree barks and nuts that play a pivotal role in the livelihoods of communal people (Mufandaedza, Moyo, & Makoni, 2015). It is therefore important to understand the traditional use and handling of indigenous fruits. Ethnic groups in southern Africa have a long history of gathering and preserving indigenous fruits (Maroyi, 2011). For example, Akinnifesi et al. (2004) stated that in Malawi, availability of *Uapacakirkiana* fruits during food shortage periods contributes to the diet. People use the income from sales to purchase household necessities.

Apart from selling indigenous fruits, rural communities consume them, either fresh or processed. Traditional processing and/or preservation help to extend the shelf life of the fruits for consumption during periods when fruits are not in abundance or not in season, as well as adding variety to the diets. Knowledge of the traditional processing of indigenous fruits is an essential step towards commercialization of some of the fruits.

Maroyi and Cheikhoussef (2017) noted that cultural beliefs intertwine with the use of indigenous fruits by various ethnic groups. Apart from being consumed as food, the fruits are used for medicinal and traditional ritual purposes. For example, in some communities, the bark, leaves, roots, and fruit of indigenous fruits trees are used for medicinal purposes. However, these trees are customarily not used as firewood (Kadzere, Watkins, Merwin, Akinnifesi, & Saka, 2017; Ramadhani, 2002).

Indigenous fruits such as *Adansoniadigitata* L., *Azanzagarckeana* (F. Hoffm.), *Berchemia discolor* (Klotzsch), *Parinaricuratellifolia* (Planch. Ex Benth), *Sclerocaryabirrea* (A. Rich.), *Strychnoscocculoides* (Baker.), *Strychnos spinosa* (Lam.), *Uapacakirkiana* (Mull.Arg.), *Vangueria infausta* (Burch.), and *Vitex payos* (Lour.) Merr are widely distributed in Zimbabwe and sold on local markets and roadsides when in season (Ramadhani, 2002). However, information on local processing/preservation, consumer preferences, beliefs, legislation, and marketing of indigenous fruits in Zimbabwe is limited.

This information can be of importance to scientists, NGOs, and government-funded programs that have an interest in the value addition of indigenous fruits. Therefore, the current study sought to investigate the traditional methods used during harvesting and post-harvest handling of edible indigenous fruits in the four districts of Zimbabwe, namely; Chirumhanzu, Gokwe South, Shurugwi, and Chivi.

2. MATERIALS AND METHODS

The Midlands State University Faculty Research Ethics Committee approved the survey method under clearance number FSTech 001/01/23.

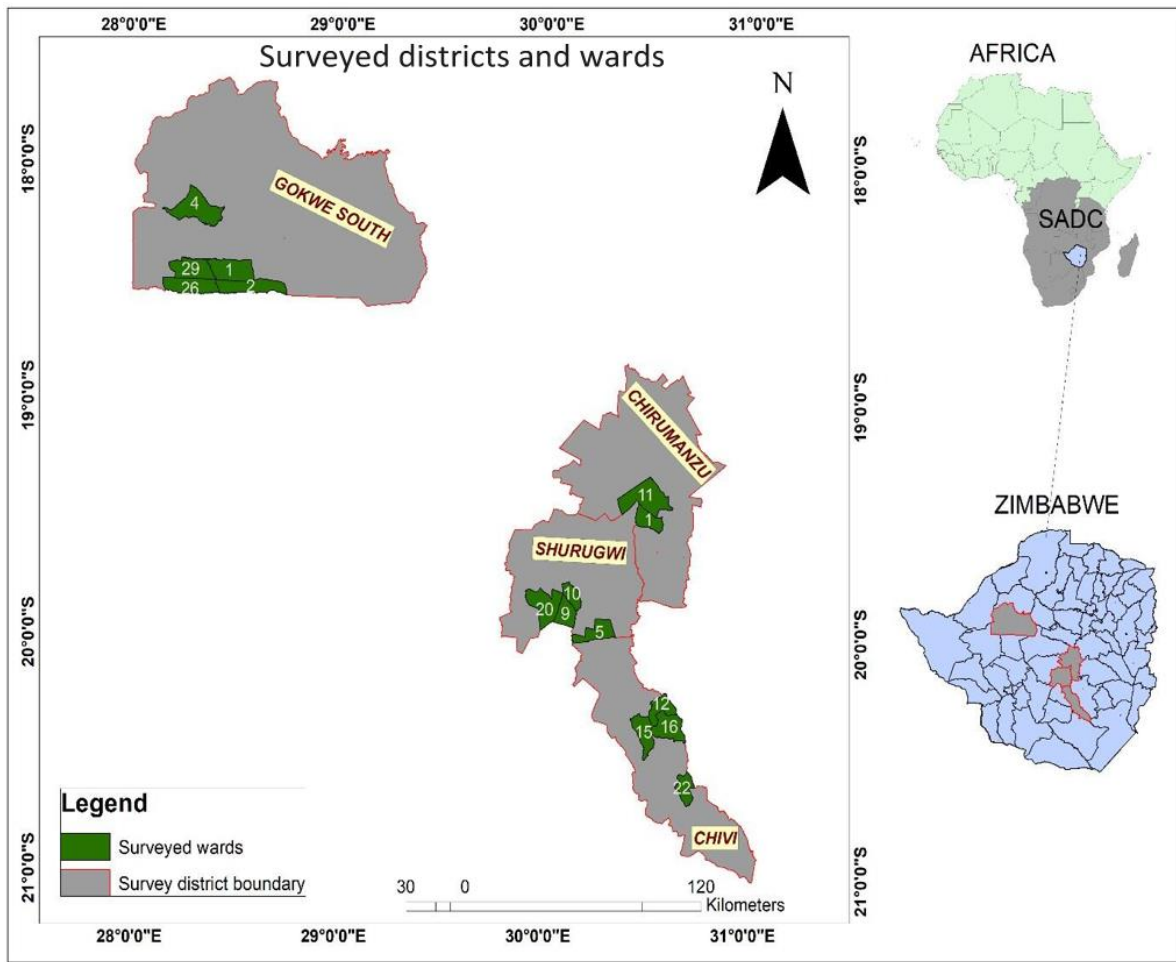


Figure 1. Study areas surveyed for indigenous fruits traditional processing and handling methods in Zimbabwe.

Note: Chirumhanzu - Mangwende 1, Mushaikwa 1, Chaminana 1, Mapiravana 1, Mudzingwa 1, Fairfields 11; Gokwe south - Gokwecentre 1, Nemangwe 2, Manoti 29, Mkoka 26, Sai 4; Shurugwi - Maroora 9, Nhema 5, Gonye 9, Pakame 20. Mzimba 9, Chachacha 10; Chivi - Zinhumwe 22, Dhonono 22, Chivasa 22, Mazorodze 12, Madziva 12, Mhare 15, Mafidhi 15, Mazani 15, Ruzive15, Madzore 15, Gandashanga 16, Tumburai 22, Manyida 15, Mazowani 22, Chegova 15, Matsveru 15.

2.1. Description of Study Area

The study was carried out in Chirumhanzu, Gokwe South, Shurugwi, and Chivi districts in Zimbabwe (Figure 1) in April 2021. The study sites were selected following a baseline survey that was conducted in Chirumhanzu, Chivi, Mberengwa, and Gokwe South in 2020. The first three districts are in the Midlands province, while Chivi is in Masvingo province. However, Chivi shares a border with the Midlands province and has vegetative cover similar to some parts of the Midlands province. The Midlands province is located in the central part of Zimbabwe and is home to almost every Zimbabwean ethnic group. Wild edible fruits are an important dietary component and source of income in the communal Midlands province (Maroyi & Cheikhyoussef, 2017). On the other hand, Masvingo province is one of the driest regions in Zimbabwe, with a predominantly savanna grassland type of vegetation (Chapungu, Nhamo, Gatti, & Chitakira, 2020). It has seven districts, including Chivi, which is rich in indigenous fruit trees as well as an existing culture of indigenous fruit utilization.

2.2. Data Collecting Tools: Pilot Study and Field Survey

In February 2021, a group of 20 respondents participated in pilot tests to assess the feasibility of the questionnaires. An unstructured questionnaire, which included questions on demographics, types of wild fruits common in the selected areas, seasonal availability, harvesting, processing and preservation methods, preference, frequency of consumption, marketing, and feasibility of commercialization, was used. We also collected data

through focus group discussions and pre-tested questionnaires for validation, enabling significant corrections before the final administration of the main survey.

We collected field survey data in April 2021, using a semi-structured questionnaire. The questionnaire captured information on the demographic characteristics of the respondents, types of indigenous fruits available, their harvesting, handling, traditional beliefs, and marketing. We translated the questions from English into the local languages. [Appendix 1](#) presents the consent form that was signed by the respondents before participation in the study. [Appendix 2](#) presents the semi-structured questionnaire used for data collection.

2.3. Sampling Procedure

We selected the respondents using purposive and snowball sampling. Briefly, purposive sampling method was used to get information on relevant communities and wards that had high indigenous fruit tree distribution from the Agricultural Extension (Agritex) officers, who provided maps and identified informants that had wild fruit knowledge. These included fruit vendors, educators, the elderly, and households in communities where these fruits were in abundance. We then used snowball sampling to identify respondents. The researcher was referred to the first respondents by key informants, and the next respondent was asked to identify consecutive random respondents. Permission to conduct the survey was obtained from the district administrators, councilors, and chiefs, who in turn identified villages and other respondents relevant to the study. A written informed consent was obtained from each participant prior to administration of questionnaires. The inclusion criteria were; children from 13 years old (high school level); and adults above 65 years old. The exclusion criteria were children below 12 years of age. For child vendors under 18, a written consent was obtained from their guardians.

2.4. Statistical Analysis

We coded and analyze the responses using the Statistical Package for Social Sciences (SPSS) software version 20. Descriptive statistics such as frequencies, pie charts, factor analysis using the principal component analysis and logistics regression were used.

3. RESULTS AND DISCUSSION

3.1. Demographic Characteristics

A total of 150 respondents were interviewed. Among these 16.6% (n=25) were from Chirumhanzu, 44.6% (n=67) Chivi, 16.6% (n=25) Gokwe South and 22% (33) Shurugwi.

Table 1. Demographic and socio-economic status of respondents.

Parameter	Specification	Frequency (n=150)	Percentage (%)
Age	13-34	37	24.7
	35-54	77	51.4
	55 & above	36	24.0
Gender	Males	73	48.7
	Females	77	51.3
Ethnicity	Ndebele	1	7.0
	Shona	134	89.3
	Kalanga	15	10.0
Source of income	Farming	73	48.7
	Trading	15	10.0
	Formally employed	57	38.0
	Unemployed	5	3.3

Most of the respondents (75.4%) were in the age group 35-75 as shown in [Table 1](#). A small group (24.7%) consisted of youths (13-34). Children aged 13-18 years formed part of the respondents as they were involved in

fruit harvesting during cattle herding and farming. It was observed that some of the children interviewed were vendors, and they assisted their guardians in selling indigenous fruits among other food items. They also took part in transportation of the fruits to roadside markets. Usually, the elderly have deeper knowledge of the types and utilization of indigenous fruits, which they also pass on to the younger generation. The youths were observed to be actively involved in harvesting and marketing of the indigenous fruits on the local markets. The majority of the respondents were from the Shona ethnic group (89.3%), while the rest were Kalanga (10%) and Ndebele (7.0%).

Most of the respondents were farmers (48.7%), while, (10%) were traders; 38% were formally employed, and 3.3% were unemployed. Farming is the most common source of income in rural areas. Apart from farming, people in communal areas also gather firewood and wild fruits for their own use and for sale. This shows that rural communities make use of locally available resources to cater for their livelihoods. This observation was in agreement with findings by Maroyi and Cheikhoussef (2017) who noted that people in the communal areas of Zimbabwe were dependent on plant sources for their diet and livelihoods.

Table 2. Reasons for consuming indigenous fruits.

Response	Frequency (n=150)	Percent
As a snack	34	22.7
They have essential vitamins and minerals that are good for the body	107	71.3
They have medicinal properties	63	42.0
Because other people consume them	9	6.0
It is our tradition	38	25.3
They are readily available	61	47.0
They are cheap	25	16.6

3.2. Why People Consume Indigenous Fruits

Preferences and attitudes towards indigenous fruit consumption are important for promoting the consumption of indigenous fruits and value addition. Indigenous fruits are generally regarded as poor man's food and are associated with people from rural areas who cannot afford exotic fruits (Ramadhani, 2002). This suggests that attitudes, availability, and accessibility affect the utilization of indigenous fruits. According to this survey, 71.3% of the respondents (Table 2) indicated that they consumed indigenous fruits because of their rich content of essential vitamins and minerals that are beneficial to health. The respondents also indicated that they consumed indigenous fruits because of their medicinal properties. For example, Chigora, Masocha, and Mutenheri (2007) stated that juice from *Strychnos spinosa* as a treatment for gonorrhoea and genital warts. Ripe fruits and leaves from *Ziziphium mucronata* were used to treat boils. The respondents (47%) indicated that they consumed indigenous fruits because they were readily found in the community fields, forests, and homesteads. Some of the respondents (25.3%) also indicated that they consumed indigenous fruits as a traditional practice or habit that dates back to the hunter and gatherer era (Harris & Mohammed, 2003; Maroyi, 2011). Most cultures tend to follow the diets, ways of living and beliefs that have long been held by their forefathers. However, a few of the respondents (6%) stated that they consumed indigenous fruits because other people consumed them. They stated that they saw their elders consuming the wild fruits and therefore followed suit. This confirms the consumer behavior theory, which states that people of the same culture, nationality, geographical location, or religion can influence future generations' attitudes and behaviors towards a product (Ramadhani, 2002).

A few of the respondents stated that indigenous fruits were cheap because they were harvested for free and everyone in the community had equal access to them. They also indicated that they did not incur costs during harvesting except for instances where they harvested the fruits in bulk and there was no need to transport them to the market. Some of the harvesters reported that they used animal-drawn carts to carry their fruits to the market. It was also observed that traditional leaders set regulations on the sale of indigenous fruits. For example, they

normally discourage selling indigenous fruits in bulk as they believe the fruits were gifts from the creator or ancestors.

3.3. Frequency and Times of Consumption

About 45.3% of the respondents stated that they consumed indigenous fruits at least twice a week when they were in season, whereas 44.6% stated that they consumed the fruits on a daily basis when in season. In order to be able to keep the fruits fit for consumption, whether on a daily, weekly, or monthly basis, some households preserve the fruits using methods such as burying them in the ground, drying them or cooking them. Other studies reported that drying and salting were often used to preserve the fruits for future consumption (Ngadze, Verkerk, Nyanga, Fogliano, & Linnemann, 2017; Nyanga, Nout, Gadaga, Boekhout, & Zwietering, 2008). Frequency of consumption of wild fruits is a personal choice and is also influenced by access and storage factors. Weekly consumption, may be explained by the fact that in some areas there are long distances between the forests where the fruits are collected and the homesteads. The current study concluded that the high consumption frequency in rural areas made indigenous fruits easily accessible.

The results also showed that all age groups, irrespective of income status, consumed indigenous fruits. This was contrary to observations in other studies that consumption of wild fruits and vegetables was associated with poverty. In general, the consumption of wild fruits is influenced by the availability, accessibility, and perception. International tourists are also known to purchase and consume wild fruits, which they consider nutritive (Mabaya, Jackson, Ruethling, Marie, & Castle, 2014).

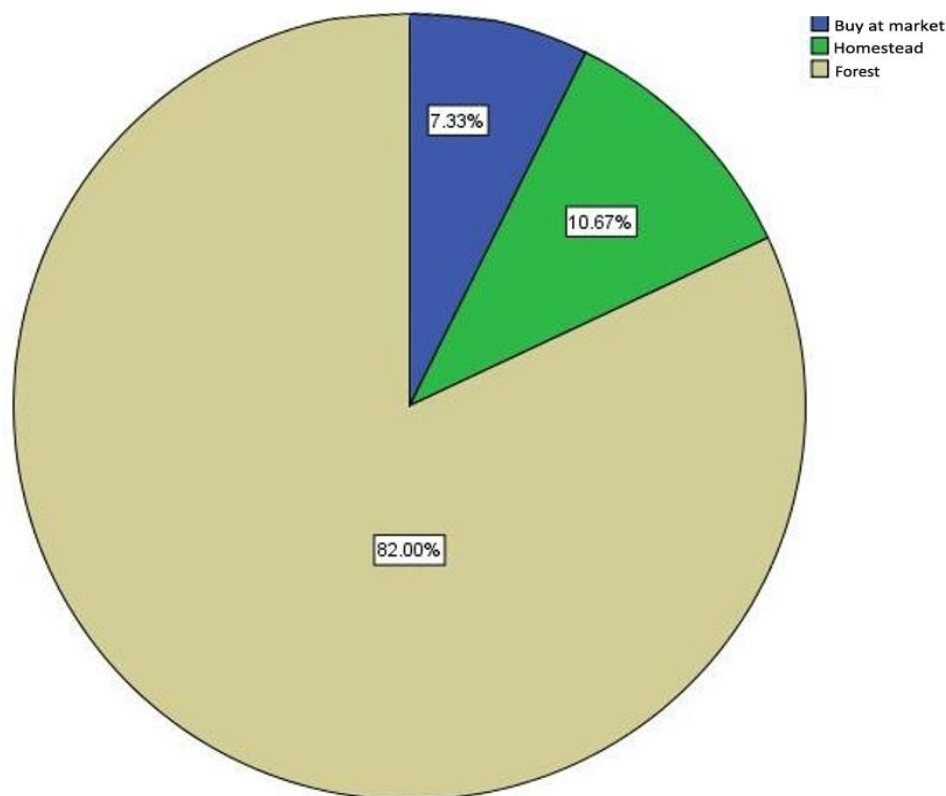


Figure 2. Major sources of indigenous fruits in Chirumhanzu, Chivi, Gokwe South and Shurugwidistricts.

3.4. Main Sources of Indigenous Fruits Consumed

The majority of respondents (82%) stated that they obtained indigenous fruits from the wild (Figure 2). The forests in the study area have high diversity and distribution of trees. Only (10.7%) highlighted that they got their fruits from their own homes and fields.

Some households reported that they cultivated indigenous trees in their homesteads for easy access to the fruits and for other purposes such as providing shade and acting as windbreaks. A study conducted in Bikita and Chimanimani districts by Ngadze et al. (2017) found that *Strychnos spp.* fruit trees were found around the fields and homesteads, and they could have been retained during clearing of land or cultivated. This was in agreement with the observation made by Akinnifesi et al. (2004) that indigenous fruit trees in Zimbabwe were usually found in forests, homesteads, grazing, and cropping fields.

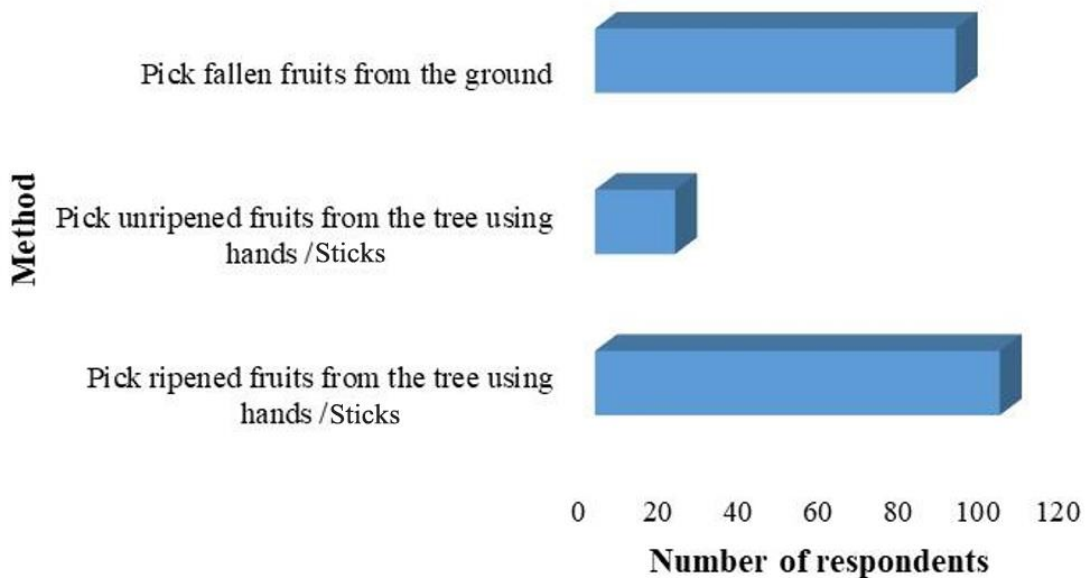


Figure 3. Harvesting methods employed for indigenous fruits in Chirumhanzu, Chivi, Gokwe South and Shurugwidistricts.

3.5. Harvesting Methods for Indigenous Fruits

The fruit collectors reported that they used their senses of sight, smell, and taste to determine whether the fruits were ready for harvesting. This was in contrast to commercial harvesting of exotic fruits, where maturity indices are normally used (Mothapo, 2014). The respondents cited picking ripened fruits from the ground and dislodging ripened fruits from the mother tree using sticks or hands as the main methods of harvesting indigenous fruits (Figure 3). These methods can result in physical damage to the fruits and subsequent loss in quality. Most respondents in the surveyed communities preferred harvesting ripe fruits for both consumption and marketing. About 13.3% of the respondents stated that they harvested the fruits before they were ripe. Those who harvested unripe fruits argued that the demand for some indigenous fruits such as *U. kirkiana* and *S. cocculoides* was now high, and waiting for the fruits to ripen would be a risk due to competition by other fruit collectors. In a separate study, Ngadze et al. (2017) made similar observations. They would bury the unripe fruits in a small pit in the ground in order to store them. The fruits are placed in direct or indirect contact with the soil. Burying unripe fruits decreases chances of rotting as the pace of the ripening process is carefully monitored. In addition, the fruits are protected against harsh atmospheric conditions and thereby preventing shriveling, of the fruits (Kadzere et al., 2017; Rampedi & Olivier, 2013).

Harvesting techniques have a direct impact on fruit quality. Conventional harvesting techniques are known to increase post-harvest losses due to lack of control over factors such as temperature, humidity, and ripening rate, among others. In commercial harvesting, the fruits are harvested based on specific maturity indices to determine the timing of harvesting. Ergonomical harvesting techniques involving the use of specialized harvesting bags, grading, precooling of harvested produce and maintenance of a cold chain from transport, storage to the final consumer, are used (Gross, Wang, & Saltveit, 2016). This maintains the quality of the fruits in the value chain.

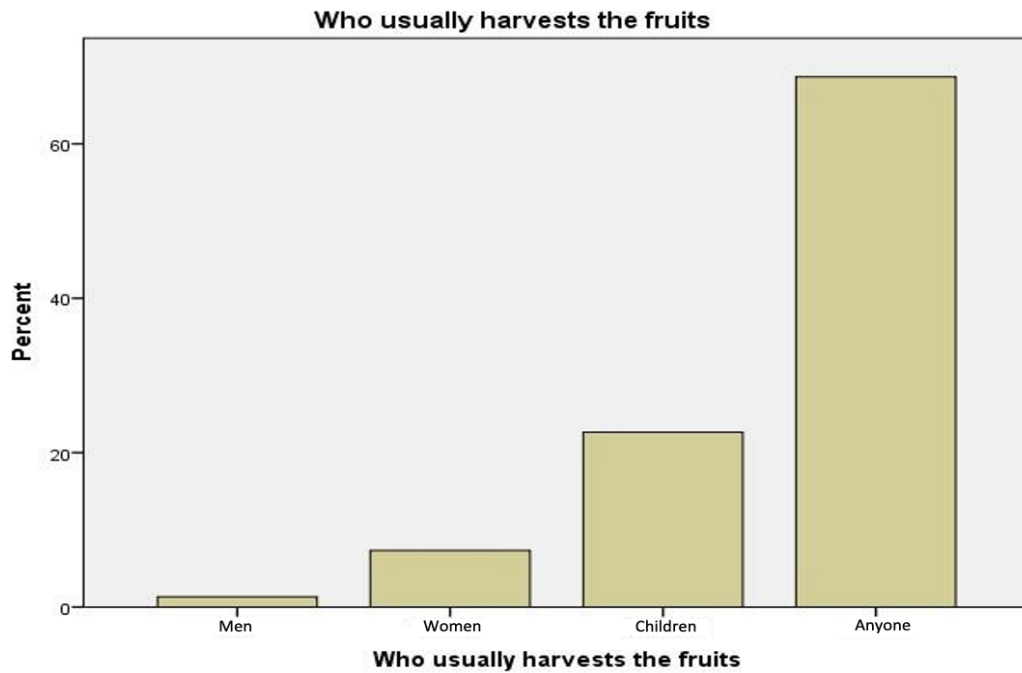


Figure 4. Gender roles in harvesting indigenous fruits in Chirumhanzu, Chivi, Gokwe South and Shurugwidistricts.

3.6. Who Usually Harvests Indigenous Fruits?

As shown in Figure 4, harvesting of wild fruits is done by anyone, irrespective of age or gender (68.7%). However, some respondents indicated that women and children, who normally collect firewood from the forests and herd cattle, harvested the wild fruits. A few respondents (1.3%) indicated that men harvested wild fruits during hunting or when they specifically harvested fruits in deep forests (*Jiri remazhanje*) or sacred places. The general observation was that, responsibility for harvesting indigenous fruits depended on the structure of each household.

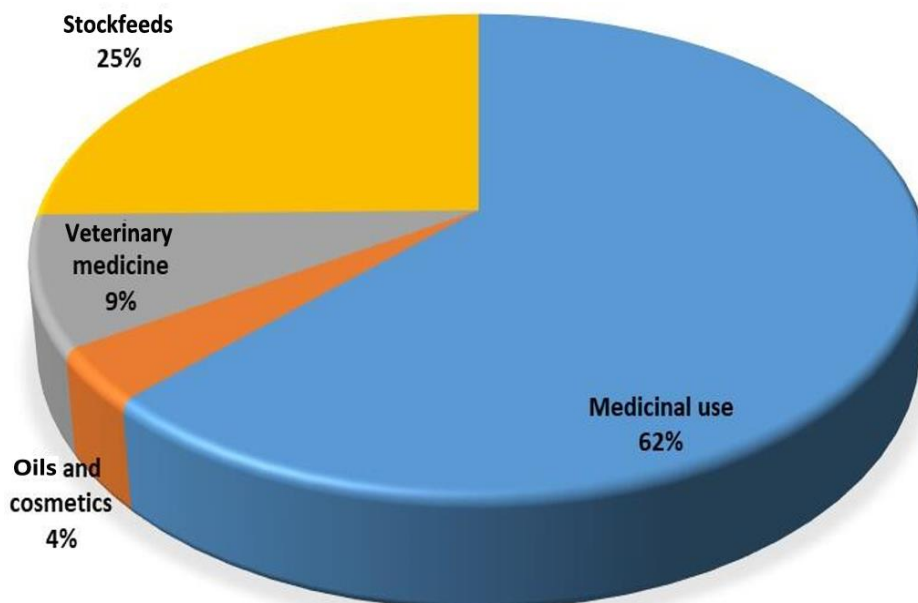


Figure 5. Other uses of indigenous fruits in Chirumhanzu, Chivi, Gokwe South and Shurugwidistricts.

3.7. Other Uses of Indigenous Fruits

Most of the respondents (70.6%) indicated that they used indigenous fruits for medicinal purposes. Besides the bark, roots, and leaves, the pulp of some wild fruits was also used to treat various ailments (Figure 5). For example, people consume the pulp of *Garcinia buchananii* Baker as an aphrodisiac. *S. spinosa* Lam. fruit extract is drunk as a

remedy for gonorrhoea and genital warts, and *Ziziphismucronata*. Wild fruit powder is used to treat boils (Chigora et al., 2007; Maroyi, 2011; Maroyi & Cheikhoussef, 2017). The current study also showed that 26% of the respondents used indigenous fruits for veterinary medicinal purposes. About 26.6% of the respondents stated that indigenous fruits can be used as stock feed. It was previously reported that *Piliostigmathonningii* (Schumach.) Milne-Redh. (*masekesa*) pods were used as animal feed for beef and dairy production in Zimbabwe (Mandibaya & Chihora, 1999).

Other studies have documented the diverse applications of parts from indigenous wild fruits. For example, *A. digitata* (baobab) seed oil can be used to make cosmetics, and after extraction of oil, the hard shells are used as feed for chickens, goats, and cattle (Darr, Chopi-msadala, Namakhwa, Meinhold, & Munthali, 2020; Lisao, Geldenhuys, & Chirwa, 2017). *P. curatellifolia* (mobola plum) fruits can be crushed, mixed with water, and applied to leafy vegetables as a pesticide (Brazier, 2020).

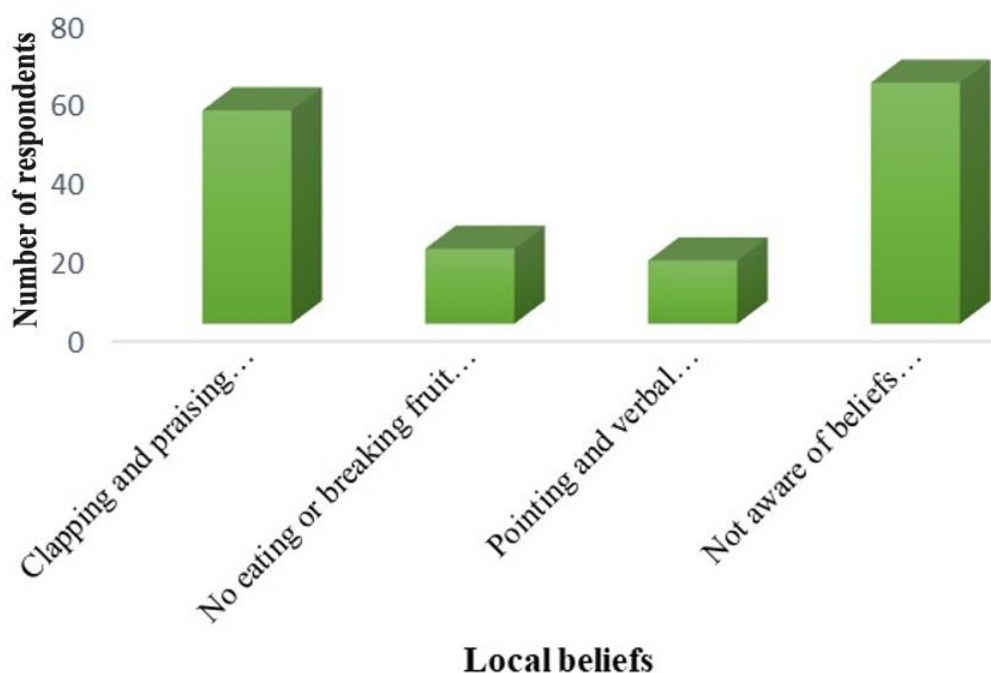


Figure 6. Traditional beliefs governing indigenous fruits in Chirumhanzu, Chivi, Gokwe South and Shurugwi.

3.8. Traditional Beliefs and Laws Governing the use, Selling and Conservation of Indigenous Fruit Trees

The study observed various practices that were associated with belief systems. About 4% of the respondents indicated that they were not allowed to comment about the quality of the fruits when harvesting or eating certain indigenous fruits, as that would be a sign of disrespect to the ancestors who gifted them the fruits (Figure 6). However, they noted that the younger generation no longer observed these beliefs. About (36%) indicated that according to their beliefs, they had to first thank the ancestors by clapping their hands before harvesting some indigenous fruits; 12.6% stated that they were not allowed to eat or break fruits near the mother tree. In Gokwe South, the Kalanga stated that they were not allowed to eat or break the fruits near the mother tree as it was regarded as a taboo. It was believed that if one failed to obey this belief, the mother tree would dry up. Some (10.6%) of the respondents indicated that they were not allowed to point directly at the tree. For example, in Nemangwe village, Gokwe, there was report prohibiting anyone from pointing directly at an indigenous tree during their search. Failure to adhere to this belief would result in confusion and failure to locate the tree. 2.6 % of respondents highlighted that community regulations only allow harvesting of fallen fruits.

Harvesting fallen fruits is a common practice amongst the people in Gokwe South, as they believe it reduces damage to the mother tree and is a way of respecting the ancestors. The other rationale was that it was a way of

conserving fruits through controlled harvesting, as the ripe fruits are used first before the unripe ones on the tree. This prevented post-harvest losses and rotting of fallen ripe fruits. These beliefs promote the sustainable use of wild fruit trees, as communities hold them in high regard and protect them from deforestation. Other respondents (36%) stated that they did not follow or have beliefs in relation to harvesting and consumption of indigenous fruits in their area. Brazier (2020) reported that in the African custom, it was believed that when people respected nature, the ancestors would respond by giving good rain and fortune. *P. curatellifolia* fruit tree is regarded as sacred and used for rainmaking and field protection rituals (Brazier, 2020). Various communities in Zimbabwe believe that ancestral spirits reside under *S. birrea* and *P. curatellifolia* trees, and for that reason, it is a taboo to cut down these trees (Brazier, 2020; Brazier, Mayer, & Jacquet, 2020). Ramadhani (2002) also reported that in Chivi and Zvishavane it was considered taboo to cut down fruit trees such as *Strychnospotatorum*, *P. curatellifolia*, *A. garckeana*, *A. digitata* and *Lannea. discolor* trees. With the advent of Christianity and modernization of the world, some of these traditional beliefs are now being ignored and lost together with traditional knowledge systems. About 20.6% stated that it was an offence to cut down indigenous fruit trees. Local government regulations regard cutting down of fruit trees as an offence and it is prohibited by the local chiefs and leaders. We protect the indigenous fruit trees for practical purposes. They are regarded as a source of food, shelter, and spiritual purposes. Anyone who is found cutting wild fruit trees is fined. Local authorities are advocating for wild fruit tree conservation, especially during clearing of land for agricultural purposes.

About 41.3% of the respondents stated that they were not allowed to sell indigenous fruits in their communities by the local authorities, such as headmen, or chiefs (Figure 7). This may be due to claims that indigenous fruit trees grow naturally in forests and there is no cost incurred in their growth; hence, they should remain free for everyone (Ramadhani, 2002). They also believe that the fruits are God’s gift to the community. However, it was observed that selling was permitted for area specific fruit trees that were not found in non-miombo woodlands. For example *S. strychnos*, *A. digitata*, *A. garckeana*, and *B. discolor* were among many indigenous fruits that were sold in urban markets and along highways on the outskirts of local communities. The people in areas where certain indigenous fruits were not available depended on vendors to acquire the fruits for consumption purposes. The remaining 35.5% stated that they were not aware of regulations governing indigenous fruits in their area.

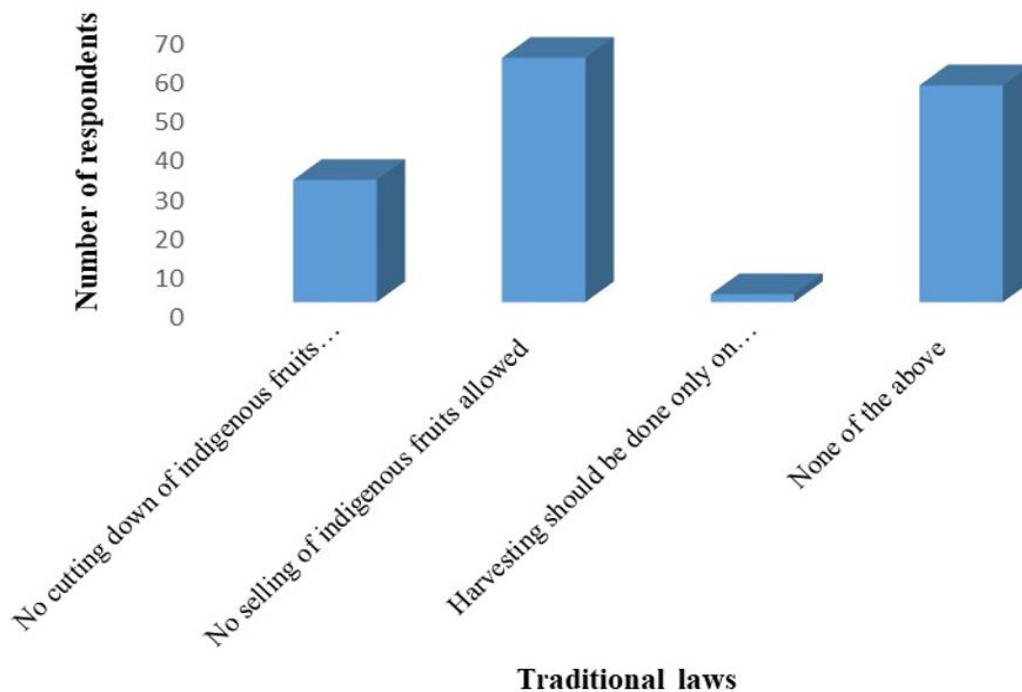


Figure 7. Traditional laws governing indigenous fruits in Chirumhanzu, Chivi, Gokwe South and Shurugwidistricts.

3.9. Processing and Preservation of Indigenous Fruits

The study showed that indigenous fruits were consumed either raw or fresh, dried or processed into different products. However, consumption of fresh fruits was more common among the respondents (70%). Women and children usually collected wild fruits when they were looking for firewood or herding cattle. About 20% of the informants indicated that they processed extra fruits into products such as beer, juices, condiments, and peanut butter. Previous studies reported that *S. birrea* fruit juice and pulp were processed into *mukumbi* beer (Gadaga, Mukutumira, Narvhus, & Feresu, 1999) thin porridge (Ngadze, Linnemann, Fogliano, & Verkerk, 2019) juices and jams (Bucheyeki, 2008).

Some of the respondents mentioned using *S. cocculoides* (*matamba*) fruit pulp was used to make a thin porridge called *mutandabota*. They explained that they first cracked the shell to remove the seeds before making the porridge. They then mixed the fruit pulp with water and maize meal to make the porridge. Previous studies reported that the pulp extract from *P. curatellifolia* (*hacha*) fruits was used to make jam (Muchuweti et al., 2013).

About 10% of the respondents highlighted that the most common methods of preserving wild fruits were sun drying and boiling with salt. The practice of boiling in salt before drying was usually used for *A. garckeana* (*matohwe*) and *P. curatellifolia* (*hacha*) fruits. Dried fruits can last for months or years, depending on the level of dryness and storage conditions.

The respondents highlighted several constraints during traditional processing and preservation of indigenous fruits. For example, 5.3% of the respondents indicated that they did not have other necessary ingredients, such as sugar and salt that are needed to produce their desired products.

Other respondents (2%) indicated that they did not have knowledge of processing fruits; hence, they just consumed them raw. The latter group was mainly composed of youths who had limited know-how about the traditional processing of fruits.

The majority of the respondents highlighted that they lacked capital to buy equipment. For hygienic reasons, processing of fruits into powder or ground pulp is now done using modern equipment in both large and small-scale processing. According to the respondents, household processors were moving away from using pestle and mortar (*duri*) for pounding and stones for pressing fruit pulps into juice and were now using sacks and mutton cloths to press the ripe fruits for juice. There is lack of standardized control in traditional processing of wild fruits, and the operation is tedious. To curb these problems, processors prefer using light equipment, which is more efficient, hygienic, and faster.

However, few can afford such equipment. We observed that 33.3% of the respondents lacked proper storage facilities for processed products. For example, wild fruit juice processed at household level needed to be stored at cold temperatures to prolong shelf life. Most rural households do not own refrigerators due to lack of electricity. As a result, some of the processed fruit products are quickly consumed at household level and barely make it to the market. Products such as fruit-based alcoholic beverages that are preserved through fermentation keep longer than the fresh fruit juices.

In Shurugwi and Chivi, *mukumbi* beer from *S. birrea* (*mapfura*) or *P. curatellifolia* (*hacha*) was commonly sold during gatherings though it only kept for a few days to a week. Baked products, such as, porridge, peanut butter, jam, from indigenous fruits were, mainly for household consumption. Dried fruits were mainly consumed at home or sold at the local market.

Suggested solutions for the processing constraints included training on value addition (38%), capital injection (3.3%), proper equipment and ingredients to use (26.7%), and alternative preservation methods such as chemicals, refrigeration, and solar drying (47.3%).

Table 3. Prices of indigenous edible wild fruits sold at Chirumhanzu, Gokwe South, Shurugwi and Chivi local markets.

Fruit	Price per 250 ml cup (US\$)	Price per plate (US\$)	Price per gallon (5L) (US\$)	Price per fruit (US\$)
<i>Berchemia discolor</i> (Klotzsch) Hemsl.	0.50 -1	-	2.50	-
<i>Azanzagarckeana</i> (F.Hofm.) EXell&Hillc.	0.50 -1	0.50-1	-	-
<i>Vangeriopsis lanciflora</i> (Hiern) Robyns	1	-	-	-
<i>Strychnos madagascariensis</i> Poir.	1	1	-	-
<i>Vangueria infausta</i> (Burch)	0.50-1	1	-	-
<i>Vitex payos</i> (Lour.) Merr.	0.50 -1	1	0.75- 2	-
<i>Mimusops zeyheri</i> Sond.	1	-	-	-
<i>Diospyros mespiliformis</i> Hochst. Ex A.DC.	0.50 -1	-	-	-
<i>Flacourtiaindica</i> (Burm.f.) Merr.	0.50	-	-	-
<i>Strychnos spinosa</i> Lam.	-	-	2	0.20 - 0.50
<i>Strychnos pungens</i> Soler.	-	-	-	0.20
<i>Adansonia digitata</i>	0.50	-	-	0.20 - 0.50
<i>Uapacakirkiana</i>	-	0.50 -1	1-5	0.20
<i>Ziziphus mauritiana</i> Lam.	1	-	2.50	-
<i>Parinaricuratellifolia</i> Planch. Ex Benth	-	-	-	0.10
<i>Syzgium cordatum</i> Hochst. Ex C. Krauss	0.50	-	-	-
<i>Strychnos cocculoides</i> Baker	-	-	-	0.20
<i>Flueggea virosa</i> (Roxb. ex Willd.) Voigt subsp. virosa	-	-	1	-
<i>Ximeniaca affra</i> Sond. Var. caffra	-	1	-	-

Note: US\$, United States dollars; L, Litres.

3.10. Economic Value of Indigenous Fruits

Indigenous fruits, like other indigenous foods, are a source of income for many rural households and contribute to their livelihoods (Akinola, Pereira, Mabhaudhi, de Bruin, & Rusch, 2020). In many countries in Africa, selling of indigenous fruits is done by smallholder farmers in informal markets (Mabhaudhi, Chimonyo, & Modi, 2017). The informal market is not controlled or regularized, so the wild fruit value chain procedures are subjective. According to the findings, anyone could sell indigenous fruits, regardless of age and gender. The price and unit of measurement were dependent on the season, fruit availability, market location, and target customers. In a separate study, Ramadhani (2002) noted that the cost of transporting indigenous fruits from harvest area to the market determined the final price. Another factor that influences the price could be the popularity of the fruit. The study showed that the prices ranged from USD 0.10-0.50 per fruit for big fruits such as *S. cocculoides* (Table 3). The containers used as units of measurement were 250-ml cups, plates of various sizes, 5L containers, and 20L buckets. It was also noted that the price of indigenous fruits was higher in urban areas than in rural areas, where they were in abundance. Grading fruits was not a priority among traders on roadside markets. The wild fruits were mixed with little or no attempt to grade them according to color, size, or ripeness. It was observed that the fruits were rarely washed as a way of increasing their shelf life unlike, exotic fruits, which are washed, graded, and packed uniformly. The controlled activities in the exotic fruit value chain, make the fruits more hygienic, acceptable, and popular than indigenous fruits.

The study showed that consumers bought fruits of their choice based on different characteristics such as taste, size, color and ripeness. This is consistent with observations by Karaan et al. (2006) that consumers usually rely on their five senses when buying food products. The taste and color aid in preference determination, and the size is an indicator of the value for money of the fruit to the customer. However, indigenous fruits are sold mixed in informal markets, which makes product selection difficult.

4. FACTOR ANALYSIS - PRINCIPAL COMPONENT ANALYSIS

We conducted Principal Component Analysis (PCA) to identify the variables that explain postharvest handling of indigenous fruits. The PCA showed that 16 components were important. The extraction rate was above 75%, with a cumulative variance of 76.9% with each factor explaining a minimum of 2.50% and a maximum of 9.08% of

the total variance. All the questions with a variance above 0.5 contributed significantly to answering the research questions and gave a clear picture of indigenous knowledge systems associated with post-harvest handling of indigenous fruits (Table 4). They gave a positive variance, as shown in Figure 8. The study showed that there were significant differences in the opinions of respondents in relation to these 10 questions, which shows variation in their points of view and the way they harvest, process, and market indigenous fruits. The variations were probably due to differences in age, gender, culture, and geographical location. The questions with values closer to the center showed greater variation in responses as compared to the ones further from the center.

Table 4. Principal component analysis.

Variable	PC1	PC2	PC3	PC4	PC5	PC8
Eigenvalue	3.906	3.680	2.968	2.731	2.391	1.885
Variability %	9.084	8.558	6.903	6.352	5.560	4.384
Cumulative	9.084	17.642	24.546	30.898	36.457	50.755
Factor loadings*						
Q2.4a What is the frequency of consumption of wild fruits?	-0.112	0.634	0.161	0.201	-0.092	-0.005
Q2.9a What are the other uses of wild fruits besides consumption?	0.335	-0.488	-0.085	0.331	0.513	-0.126
Q3.1c What are the traditional beliefs concerning fruits relevant in your area?	0.145	-0.104	0.539	0.070	-0.075	-0.125
Q3.2b Are there any traditional laws governing conservation and selling of indigenous in your area?	-0.141	-0.123	0.554	-0.088	0.215	0.066
Q4.1c In which form do you consume the fruits?	0.577	0.150	0.159	0.091	0.330	0.236
Q4. 2a What are the challenges faced during processing and preservation of indigenous/wild fruits?	0.551	0.254	0.050	0.143	-0.147	0.295
Q4.3b What can be done to improve the way you process the fruits?	0.208	0.393	0.118	0.537	-0.132	-0.129
Q5.2 Who usually sells the fruits at the market?	-0.354	-0.164	-0.032	-0.067	-0.384	0.512
Q5.3 do you consider ripeness in buying or selecting the fruits for consumption?	0.200	-0.129	0.622	-0.046	-0.087	-0.188
Q5.4 How do you feel about promoting indigenous fruits for wider consumption in Zimbabwe?	0.622	-0.260	0.137	-0.152	-0.055	0.004

Note: PC, Principal component.

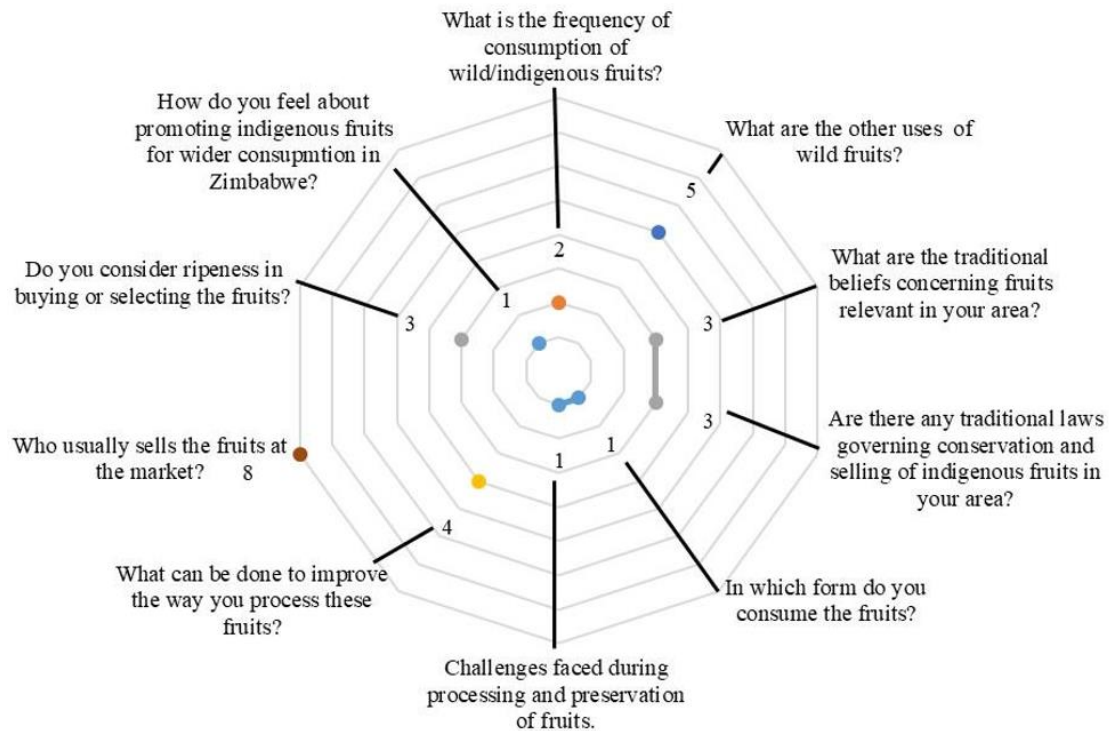


Figure 8. Principal component plot showing positive variances in indigenous knowledge regarding indigenous fruits.

4.1. Logistic Regression

Logistic regression was performed, with question 5.5, “Do you think the fruit and its product will be well received on the market?”, being the dependent variable. Step-wise regression procedures were used. Of the respondents, 126 responded “yes” and 24 responded “no” to the question. The p-values of the final and fifth iterations showed that the model was significant at 5% level. We can conclude that the model coefficients were significant. The Nagelkerke R-square is 71.3%, indicating that the independent variables in the model explain 71.3% of the variation in question 5.5 (Table 5). Logistic regression was also performed, with question 5.6, “Would you buy food products made from the indigenous fruits you mentioned if they were to be commercially produced?” being the dependent variable. Table 6 shows that the Nagelkerke R-square was 54.3%, which is the independent variable in the model; explaining 54.3% of the variation in question. This means that, the models were fairly good. There was a high likelihood (p<0.05) that indigenous fruits and their products would be successfully received and purchased on the market. Table 7’s computations yielded the following final model:

$$Q5.6 = 1.218 * Q2.8a - 1.658 * Q3.2b$$

Table 5. Logistic regression for question 5.5 model summary.

“Do you think the fruit and its product will be well received on the market?”			
Step	-2 Log likelihood	Cox & Snell R square	Nagelkerke R square
1	a	0.431	0.574
2	b	0.481	0.641
3	c	0.503	0.670
4	c	0.522	0.696
5	c	0.535	0.713

Table 6. Logistics regression for question 5.6.

“Would you buy food products made from the indigenous fruits you mentioned if they were to be commercially produced? “			
Step	-2 log likelihood	Cox & Snell R square	Nagelkerke R square
1	a	0.378	0.505
2	b	0.407	0.543

Table 7. Final model equation formulation.

Question No.	B	SE	Wald	df	Sig.	Exp (B)
a q ² - 2b	-0.839	0.116	52.168	1	0.000	0.432
b q ² - 8a	1.218	0.455	7.162	1	0.007	3.381
q ³ - 2b	-1.658	0.345	23.043	1	0.000	0.191

Note: ‘a b’ means the questions are significantly different and the answer had significant variations.

5. CONCLUSION

The study revealed that Zimbabwe is home to a variety of indigenous fruit species. The fruits commonly mentioned by respondents were *U. kirkiana*, *V. payos*, *A. garckeana*, *Ximenia. caffra*, *S. spinosa*, *D. mespiliformis*, *V. infausta*, *G. flavescens*, and *A. digitata*. Some of these fruits are eaten raw or processed into different food products at household level using traditional methods. Products made from indigenous fruits include porridges, alcoholic and non-alcoholic beverages, jam, and relish flavorings. The common harvesting techniques cited were picking ripened fruits from the ground and using sticks or hands to dislodge fruits from the mother tree. Before harvesting, the harvesters use their natural senses to determine the fruit’s maturity stage. Harvesting and selling indigenous fruits is done by all genders, including children. However, women primarily handle the processing. Some of the fruits are critical for food security, especially during drought periods. The study also showed that the fruits were consumed

by all age groups without regard to social status. It was also noted that, among the 4 districts, Gokwe South had minimal value addition as compared to other districts. The study also showed that not all indigenous fruits were sold on the market, and the most popular fruits sold included *U. kirkiana*, *A. garckeana*, *S. birrea*, *S. cocculoides*, *B. discolor*, and a few others.

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Institutional Review Board Statement: The Ethical Committee of the Midlands State University, Zimbabwe has granted approval for this study on 7 February 2023 (Ref. No. FSTech 001/01/23).

Transparency: The authors state that the manuscript is honest, truthful, and transparent, that no key aspects of the investigation have been omitted, and that any differences from the study as planned have been clarified. This study followed all writing ethics.

Competing Interests: The authors declare that they have no competing interests.

Authors' Contributions: Study conception and design, draft manuscript preparation P.N., D.T.M., T.H.G., T.Z.J.; data collection, analysis and interpretation of results: P.N. All authors have read and agreed to the published version of the manuscript.

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Appendix 1



Midlands State University

P. BAG 9055
Gweru.
Zimbabwe

Tel. (263) 54 260450/260417
260409/2604972/260632/260596
FAX: (263) 54 260753 / 54 260233

Faculty of science and technology
Department of food science and nutrition
Date: _____

Dear Sir/ Madam

Ref: Request for free voluntary consent for participation in the study

Request is being made for your participation in a survey of indigenous fruits which are commonly found in..... District. The main aim would be to identify the fruits, the uses, and consumption patterns, traditional methods of processing and economic value among other questions.

Therefore, I kindly request your time to answer the questionnaire. All the information given will be treated with strict confidentiality and used for this study only. Your cooperation in completing the questionnaire is very much appreciated.

I sincerely thank you for your time and support.

Yours sincerely,
Patience Nemapare

Consent form

2.3 List 5 indigenous fruits that you consume in order of first preference

Preference	Fruit name
1 st	
2 nd	
3 rd	
4 th	
5 th	

2.4 Why do you consume indigenous fruits? They are an indigenous snack They have essential vitamins and minerals good for the body They have medicinal properties Because other people consume them It is our tradition They are readily available They are cheap

2.5 What is the frequency of consumption of the wild fruits? Daily Weekly Monthly

2.6 At what times? Meal time Dessert Anytime

2.7 What is the source of the fruits you consume? Buy at market Homestead Forest

2.8 How do you harvest indigenous fruits in your area? Pick ripened fruit from the tree using hands or sticks Pick unripen fruits from the tree using hands or sticks Pick fallen fruits from the ground

2.9 Who usually harvests the fruits? Men Women Children Anyone

2.10 What are the other uses of the fruits besides being eaten? Medicinal purposes Oils and cosmetics Veterinary medicine Stock feed

Part 3: Legislation and traditional beliefs concerning indigenous fruit trees

3.1 Which traditional beliefs concerning the fruit are relevant in your area? No commenting allowed about the fruit Clapping and praising ancestors before harvesting the fruits necessary No eating or breaking of the fruits near the mother tree allowed Pointing and verbal identification of the fruit tree not allowed none of the above

3.2 Are there any traditional laws governing the conservation and selling of indigenous fruits in your area? No one is allowed to cut down indigenous fruit trees No selling of indigenous fruits is permitted Harvesting should be done only on fallen fruits none of the above

Part 4: Characteristics and constraints in processing and preservation of indigenous fruits

4.1 In which form do you consume the fruits? Raw and fresh Dried Processed into other products e.g., beer

4.2 What are the challenges that you face during the processing and preservation of fruits? Lack of other ingredients Lack of knowledge Lack of capital to buy equipment Lack of storage facilities

4.3 What do you think can be done to improve the way you process the fruits into other products? Training on value addition Capital injection Proper equipment and ingredients to use Use of alternative preservation methods

Part 5: Economic value of indigenous fruits

5.1 At the market, how much does the fruit cost per kg or bucket or gallon?

Indigenous fruits usually sold on the market	Price in USD	Unit of measurement (Cup; plate; gallon, single fruit)

- 5.2 Who sells the fruits at the market? Women Men Children Anyone
- 5.3 What characteristics do you consider in buying or selecting the fruits?
Taste Size Color Ripeness
- 5.4 How do you feel about promoting indigenous fruits for wider consumption in Zimbabwe? Agree
Indifferent Disagree
- 5.5 Do you think the fruit and its product will be well received on the market? Yes No
- 5.6 Would you buy food products made from the indigenous fruits you mentioned if they were to be commercially produced? Yes No
- 5.7 Why?.....
.....

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