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Research Article

Nutritional Value and Utilization of Yams (*Dioscorea steriscus*) by Residents of Bindura Town High Density Suburbs, Zimbabwe

S. Washaya,[1] J. F. Mupangwa,[1] and E. Muranda[2]

[1]*Department of Livestock and Pasture Science, Faculty of Science and Agriculture, University of Fort Hare, Private Bag Box X1314, Alice, King Williams Town 5700, South Africa*
[2]*Hermann Gmeiner High School, Private Bag Box 998, Bindura, Zimbabwe*

Correspondence should be addressed to S. Washaya; jabulaniwashaya@yahoo.com

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The objective of this study was to assess utilization levels, availability, nutritional value, and magnitude of sales by vendors of *Dioscorea steriscus* by residents of Bindura. A multistage sampling procedure was used to select respondents. Data were subjected to Chi-square, logistic regression, and correlation to determine the effects of demographic determinants on utilization of *D. steriscus*. Questionnaires were used to collect data. Results show that education status and period of stay significantly affect the consumption of *D. steriscus* ($P < 0.05$). It was also observed that consumption is frequent between lunch and supper (47%) compared to breakfast. *D. steriscus* has high iron (6.8%), ash (2.06%), and CF (16.8%) contents but it is low in protein (0.83%). Irrespective of gender of respondent, suburb of residence, size of family, period of stay, education level, employment status, and source of income, respondents will grow *D. steriscus* for use as food supplement (odds ratio = 0.475). The period of stay ($r = 0.08$) and education level ($r = 0.08$) positively affect the growing of *D. steriscus*. *D. steriscus* can be used as source of energy and can also be used possibly for medicinal purposes. Further study is required on possibility of phytochemicals and cytotoxic components to justify its use.

1. Background

Yams are herbaceous, climbing, twining, perennial monocots; they are the starchy, tuberous root of any of the various climbing vines of the genus *Dioscorea* cultivated or occurring naturally in warm regions [1]. They are native to tropical regions of Asia and Africa. Due to widespread early cultivation and transport of yams, exact origins for some species are unknown in other parts of the world. Nevertheless other species have been linked to certain areas and portions of the world. Chinese yam (*D. bulbifera*) is native to eastern Asia. Five-leaf yams (*D. pentaphylla*) are native to tropical Asia or eastern Polynesia. Zanzibar yam (*D. steriscus* and *D. sansibarensis*) is native to Africa. Water yam (*D. alata*) has been reported as native to Southeast Asia [2]. These are the few characterized species of yams across the world that are known so far [3]. There is however evidence which indicates that water yam is unknown in the wild state anywhere in the world but was first cultivated in Assam or Burma [4]. Air yam (*D. bulbifera*) is known from both Asia and Africa [1], but it is unclear if air yam is native to both continents or was introduced from one to the other. Indigenous air yam populations were also reported on Australia's northern coastline [1].

In tropical areas of Asia and Africa, yams occur at the edges or in the canopy gaps of rainforests and woodlands. Yams grow by trailing and twining other trees above ground. Vines are without tendrils and use dead stems from the previous year's growth to climb into the other vegetation [5]. Most occurring yams grow below ground tubers annually, while others can be perennial. Yams also produce aerial tubers (bulbils) [5]. Both belowground tubers and bulbils are comprised of stem tissue [6]. Yams regenerate exclusively asexually from tubers or bulbils. Yams are dioecious and produce very small flowers, if any [1]. Yam vines twine clockwise or counter-clockwise and may grow to 30 m long depending on species [1]. Leaves may reach 26 cm wide and long with petioles generally shorter than the leaf blade [5]. Yam size

Figure 1: *Dioscorea steriscus* tubers.

and appearance are also highly variable. Variability in bulbils and tubers gives a distinct characteristic in classification and identification. Plants grow rapidly in summer than in winter similarly for tuber growth. *D. steriscus* is a tropical climate yam which prefers 30°C as optimal temperature for growth and rainfall of about 1500 mm per annum. Yams grow best in loose, deep, free-draining, fertile soil. Generally yams are regarded as underutilized species in Africa and all over the world.

Underutilized or neglected crops are those plant species traditionally used for their food, fiber, fodder, oil, or medicinal properties but have been overlooked by scientific research and development workers (ICUC 2006). The term "underutilized" means that they were once grown more extensively or might be more widely grown in the future, but for economic, agronomic, or genetic reasons they are now cultivated in limited areas [2]. These plant species have significant food and/or industrial potential which remain underutilized through lack of a coherent strategy for their evaluation and development [7]. They can help to meet the increasing demand for food and nutrition, medicines, and industrial needs. These plants risk falling into disuse yet they lay a crucial role in food security, income generation, and culture of the rural poor. According to [8] these crops have a great potential to provide income to rural micro entrepreneurship. Unfortunately the lack of attention has meant that their potential value is underexploited and they are in danger of continued genetic erosion, ultimately leading to disappearance.

Many underutilized crops are collected rather than cultivated, constituting a significant share of income for those who do not have other alternatives [2]. *Dioscorea steriscus* (Figure 1) is one of the underutilized plant species and it is sold in residential areas by vendors. There is no enough information documented on this crop implying that its current and potential contribution to people's livelihood is unknown.

Approximately 1.2 billion people in the world do not have enough food to meet their daily requirements [7]. In developing countries, farmers' dependence on a few highly selective crops has caused food and nutrition insecurity and poverty in communities due to narrow food baskets. Modern agriculture practices encourage the use of wild edible plants as a supplementary food resource [9]. These underutilized species are gathered as a source of food or cash especially during "lean periods" of the agricultural cycle [2]. *Dioscorea steriscus* is one such species in Zimbabwe. Indeed *Dioscorea* spp. are listed under priority underutilized root and tuber crops for Africa, Asia, and Latin America by Wagner et al. [10]. According to Izquierdo [8] there are major gaps in our knowledge about these neglected and underutilized species and their ecology. Consequently the capacity to conserve them and improve their yield is also limited. In urban areas, the tuber is sold by vendors who move around residential suburbs. The purpose of this study is to assess utilization levels of *D. steriscus* by Bindura high density suburbs residents and to assess its availability, nutritive value, and magnitude of sales.

2. Research Methodology

2.1. Description of the Study Area. The study was carried out in Bindura high density suburbs which are located in agroecological region II b which receives annual rainfall of 750–1000 mm. Bindura high density suburbs are composed of Chipadze, Chipadze Extension commonly known as Aerodrome, and Chiwaridzo phases I and II (Municipality of Bindura Engineering Department 2003).

Habitats of *D. steriscus* areas studied were Daw Mill Farm which is 3 km from town and is located north-east of Bindura, Trojan Nickel Mine which is also 3 km and is located in the southwest of Bindura, and lastly SOS Maize-lands Farm which is 13 km away and is located in the east of Bindura town. These sites were studied for field's observations as shown in Figure 2.

Geologically Trojan area is typically a greenstone configuration composed mainly of basaltic rocks (komatiitic/tholeitic basalts and gabbro) coupled with banded iron formations and volcanic tuffs (Trojan Mine, 2007). At SOS Maize-lands the soils are from the parent rocks greenstone banded ironstone and conglomerates of the Shamva series. These give a very wide range of soils form the heavy vlei clays to the sandy loams mixed with gravel of the river deposits (Farm Planning Scheme, 1958).

At Daw Mill Farm the soils are mainly moderate deep clays to clay loams and are derived from the Shamva Grit series (Farm Planning Scheme No. 5. 1342 June 1960).

2.2. Sampling Procedures. A multistage sampling procedure was done in selecting respondents from the four Bindura high density suburbs. In this study, two suburbs, namely, Chipadze and Chipadze Extension (Aerodrome), were randomly selected from the four suburbs. Aerodrome is further subdivided into Aerodrome high and Aerodrome suburbs.

Chipadze Extension has a total of 730 houses, while Chipadze has a total of 1995 houses (Municipality of Bindura Engineering 2003). Therefore the entire population was 2705 houses. A sample of 60 households was selected from the entire population of the two suburbs (30 households per each suburb). Proportionate sampling of the houses was done in order to achieve a fair representation of houses in each suburb. Households were therefore systematically selected, questionnaires administered to each of the 10th household. In this case the household head was the target.

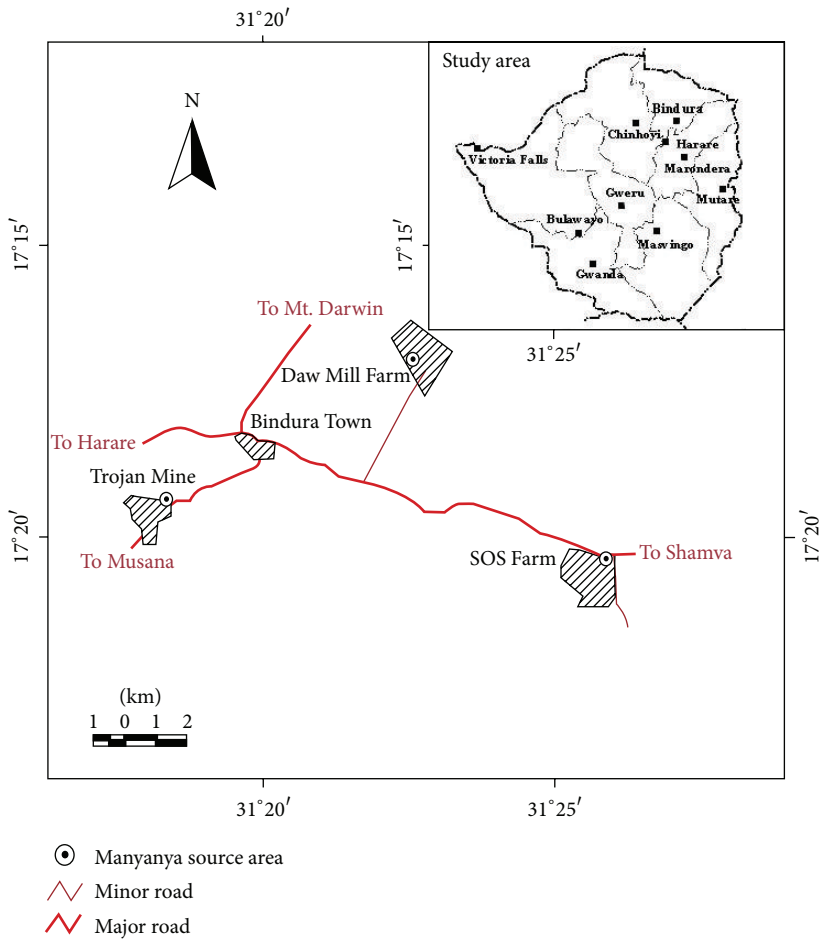

Figure 2: BUSE GIS Department: location of source areas for *Dioscorea steriscus*.

Vendors were interviewed as they were met especially during the weekends and a sample size of 30 was interviewed. These vendors are also households in their own right. Sites selected were based on vendor direction, that is, where they collected *D. steriscus*, and three sites nearest to Bindura town were selected.

2.3. Data Collection. Personal interviews were used for data collection from the residents of Bindura high density suburbs and vendors. Questionnaires were completed through face to face contact with the respondents. Samples of the tuber were dried, crushed into powder, and sent for a nutritional value analysis (proximate analysis) at the Government Analyst Laboratory in Harare Zimbabwe.

2.4. Data Analysis. The Statistical Package for Social Sciences (SPSS) Version 17.0 was used to analyze data. Pearson's Chi square test was used to analyze relationships between socioeconomic characteristics of respondents and whether they eat *D. steriscus* or not. A binomial regression analysis was used to rank factors that would lead to cultivation of *D. steriscus*.

2.5. Factors Affecting the Growing of D. steriscus. A binomial logistic regression was used to rank demographic factors (age, gender, education level, marital status, employment status, period of stay, size of family, and source of income) that would lead respondents to growing *D. steriscus* using the following model:

$$\ln\left[\frac{p}{1}-p\right]=\beta_o+\beta_1x_1+\beta_2x_2+\beta_3x_3\cdots\beta_kx_k+\varepsilon, \quad (1)$$

where p = probability of respondents ranking yes to growing of *D. steriscus* first, β_o = intercept, $\beta_1\cdots\beta_k$ = regression coefficients of ranked factors on $\ln[p/1-p]$, $[p/1-p]$ odds ratio referred to the odds of ranking location (suburb) first as a factor affecting growing of *D. steriscus* computed for each estimator $[\beta_1\cdots\beta_k]$, and ε = random residual error.

2.6. Nutritional Value of D. steriscus. The proximate content of samples was conducted by the Government Analyst Laboratory in Harare Zimbabwe. The procedure used was according to the AOAC of 1995.

Table 1: Demographic data of Bindura high density residents (N = 60).

Demography factor	Percentage	Total
Gender		
Male	13.3	100
Female	86.7	
Age		
24–35	40.0	
36–45	31.7	100
46–60	23.3	
>60	5.0	
Size of family		
<2	8.3	
3-4	43.3	100
5–7	36.7	
>8	11.7	
Marital status		
Married	58.3	
Widowed	28.3	100
Divorced	3.3	
Single	10	

Table 2: Chi square results for dependent variables which would lead to the consumption of *D. steriscus* in Bindura high density suburbs.

Variables	Consumption of *D. steriscus* (n = 60)			
	Yes	No	Chi square	Sig.
Residence	66.1	33.9	4.028	0.133
Education status	98.3	1.7	9.153	0.027*
Age	98.3	1.7	1.525	0.822
Gender of resp.	66.7	33.3	0.72	0.788
Marital status	66.7	33.3	3.87	0.527
Employment status	66.7	33.3	0.696	0.706

*Significant at $P = 0.05$.

3. Results and Discussion

3.1. Demographic Data of Bindura High Density Residents. Generally each community is different from any other one; the perceptions by that community will favor or discourage utilization of wild plants. Table 1 is demographic data for Bindura high suburb community.

The results in Table 1 show that there were more females (86,7%) than males (13,3%) in the sample. Most respondents were married (58,3%). The larger group of the sample belonged to the 24–35 years of age group (40%) and very few people were above 60 years of age (5,0%).

Chi square test of association on whether people eat *D. steriscus* or not and residence (DF; P value 4; $P > 0.05$), sex (DF; P value: 1; $P > 0.05$), marital status (DF; P value: 4; $P > 0.05$), and employment status of respondent (DF; P value: 2; $P > 0.05$) was not significant. However, there was a significant difference with respect to level of education (DF; P value: 3; $P < 0.05$) (see Table 2).

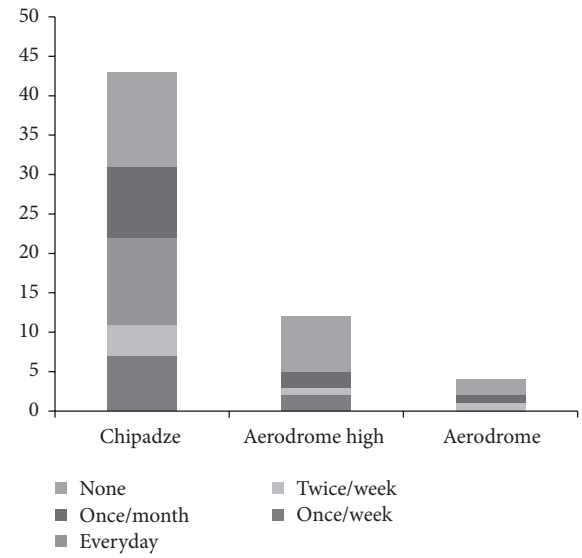

Figure 3: Frequency of eating *D. steriscus* for Bindura high density residents (N = 60).

Table 3: Frequency of *D. steriscus* meals for Bindura high density residents.

Meal	Percent
Breakfast	10.3
Lunch	38.5
Dinner	25.6
Lunch/dinner	7.7
Breakfast/lunch	17.9
Total	**100**

3.2. Frequency of Eating D. steriscus. Frequency with which the plant is used within residences was determined and Figure 3 shows these results.

Results show that 15% of the sample eats *D. steriscus* at least once a week and 20% does so every day. *Dioscorea steriscus* is a popular food crop which is taken by 45% of the sample at least once a week. The crop is therefore an integral component of the traditional food system and is readily accepted.

Results of Table 3 show that 64% of the respondents take *D. steriscus* during dinner and lunch.

3.3. Sources of D. steriscus for Bindura High Density Suburbs Residents. Since *D. steriscus* is not a common tuber, many users cannot easily find it because of its habitat characteristics; therefore the source of the tuber was also determined against this background and Figure 4 shows the results.

Most people who eat *D. steriscus* (74.4%) obtain the tuber from vendors around high density suburbs. Very few people obtain *D. steriscus* from the market (15.5) and from areas of growth (10.3%).

3.4. Selling of D. steriscus and Its Availability. *D. steriscus* is sold by vendors in and around Bindura residence; when the vendors were contacted, they also indicated their margin of

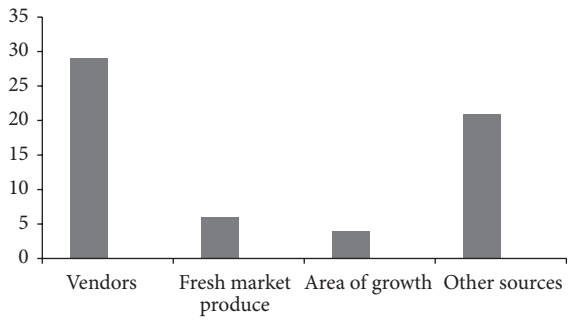

Figure 4: Sources of *D. steriscus* for Bindura high density suburbs residents.

Table 4: (a) Selling of *D. steriscus* and its availability ($N = 30$). (b) Availability of *D. steriscus* tuber in Bindura local market.

(a)

Quantity sold		Frequency of selling *D. steriscus*	
kg	%	Frequency	%
10–15	20	1-2 times per week	**76.3**
16–20	36.7	1-2 times monthly	**6.7**
21–25	36.7	Once every 3 weeks	**3.3**
≥26	6.7	Once a month	**3.3**
Total	**100.0**		**100.0**

(b)

Availability of *D. steriscus* throughout the year		
		Percentage ($N = 30$)
Season/time	June–December	56.7
	July–December	9.3
	May–December	6.7
	June–November	23.3
	Throughout the year	3.3

sales over time. Much of the crop finds its way to either consumers or the vegetable market through vendors; a result on the quantities sold is shown in Table 4(a) and time of availability is shown in Table 4(b) of this tuber in Bindura.

Vendors who sell *D. steriscus* come every week (76.3%). The frequency of selling and the quantity sold indicate clearly the potential *D. steriscus* has as a substitute for energy source especially in Chipadze area; it is also possible that if only Chipadze was to be sampled the rates of utilization of this tuber would be high (76.3%). All vendors concurred that *D. steriscus* is available from July to November (90%).

Nutritional value for *D. steriscus* was determined focusing mainly on dry matter contents and the results were obtained in Table 5.

D. steriscus is primarily used as an energy source for the study area and it seems to provide more than is necessary energy for an adult human being (93.6 cal/kg) if both CF and carbohydrate contents are considered. However the amount of protein available (0.083 g/kg) falls way below human daily requirement for an adult human being (0.8 g/kg).

Table 5: Nutrient composition of *D. steriscus*.

Nutrient	Percentage
Protein	0.83
Ash	2.06
CF	16.8
Iron	6.8
Carbohydrate	9.02
Moisture	72.5

Table 6: Logistic regression for willingness to grow *D. steriscus* in Chipadze, Aerodrome high, and Aerodrome.

Predictor	*B*	S.E.	Wald	df	Sig.	Exp(*B*)
a2	−.029	.048	.374	1	.541	.971
a3	.168	1.022	.027	1	.869	1.183
a4	.446	.343	1.691	1	.193	1.562
a5	1.570	1.765	.791	1	.374	4.805
a8	−.020	.031	.421	1	.517	.980
a9	.647	.537	1.453	1	.228	1.911
a10	−.269	.591	.207	1	.649	.764
a11	−.142	.537	.070	1	.791	.867
Constant	−1.84	2.255	.667	1	.414	.158

a2, age of respondent; a3, gender of respondent; a4, marital status; a5, size of family; a8, period of stay; a9, education level; a10, employment status; a11, source of income.

3.5. Willingness to Grow D. steriscus. Respondents were requested to indicate if they would want to grow the plant and the results are shown in Table 6.

The odds ratio of growing *D. steriscus* for this population is 0.475 if respondents are given an opportunity to do so. This means that close to half the population would want to produce their own *D. steriscus* for their consumption. The correlation matrix indicates that period of stay and education level positively affect the growing of *D. steriscus*. However the contribution was meagre (0.008%) to warrant any reliance on these factors as drivers for willingness to grow the plant within the study area.

4. Discussion

4.1. Demographic Characteristics. Most respondents (Table 1) were females because most men go to work in the Zimbabwean setup. This is in line with Jaenicke and Höschle-Zeledon [11] in Levinson, Folly, and Holland who state that men are often in jobs with frequent overtime. Because of this the responses represent the opinion of women rather than men. However it is also important to note that more than half of the respondents are married. Men spend average of nine hours per week on family care as compared to women who spend an average of 29 hours per week [11]. The respondents fall within the economically active age group (≤65 years). The minimum retirement age is 55 years and the maximum is 65 years (Government of Zimbabwe).

4.2. Consumption of D. steriscus. Most people (72%) are interested in growing *D. steriscus* which shows that it is a popular food crop for the community under study. Indeed some farmers in Zimbabwe's Rushinga District have domesticated the plant (personal communication 2011). The high levels of interest in *D. steriscus* confirm its importance to the community and hence it is worthwhile to channel resources for the development of the crop. It appears that people with higher levels of education (secondary school to tertiary) are more cautious of the danger posed by wild plants. This implies that if the plant is to be accepted across the whole education level spectrum there is need for detailed scientific analyses of the cytotoxic and antinutritional properties of *D. steriscus*. This should be followed by training of communities on how to safely prepare food from the crop.

4.3. Frequency of Consumption. Eating *D. steriscus* is irrespective of the socioeconomic characteristics of the respondents considered in this study such as sex, marital status, source of income, and employment status. According to Morisawa [12] underutilized species are traditionally food for the poor. This is in partial agreement with results of this study since the study was conducted in high density suburbs where largely the low income class resides. Izquierdo [8] also shows that indigenous vegetables are mostly a poor man's food.

Although the majorities (64%) of the respondents take the crop as lunch or dinner, the crop can also be taken as breakfast. In this respect the crop shows desirable versatility as people with different eating habits can take it when they want. The crop therefore has a huge potential to contribute to dietary requirements of the community (Table 5).

Consumption of *D. steriscus* is more common in Chipadze than in either of the Aerodrome residences (43%) (Figure 3). It is also within the same residence that people eat *D. steriscus* on a daily basis (35%). Aerodrome is primarily a medium density suburb in which the residence would not prefer the use of *D. steriscus* for food. It is within this residence where the response rates were very low and very little information could be derived from this group of people; nevertheless there are still some people who utilize *D. steriscus*. This disqualifies the fact that it is generally the poor who use neglected plants in their daily living.

4.4. Nutritional Value of D. steriscus. The average energy requirements for an adult human being can be covered beyond measure by consumption of only 100 g of *D. steriscus* (since it contains 93.6 cal/kg DM) of energy. However, the protein content is lower than human requirements per day (Table 5). An adult human being requires 8 mg/day of iron (male) and 18 mg/day (females). The results of this study (Table 5) indicate that the yam can sustain the daily iron requirements for all age groups (6.8 gI/100 g). However, elevated iron levels have been linked to cardiovascular disease, inflammatory conditions like arthritis, and cancer, most likely because of iron's propensity to *oxidize* (produce free radicals) in a liquid environment.

4.5. Sources of D. steriscus. Much of the plant is provided by vendors who seem to be conversant with the area most liked by the plant to grow. It is interesting to note that some consumers do not even know where the plant grows (personal communication 2014) but still they consume it from the hands of vendors. Typically for this community vendors know much about the plant's habitats more than anyone else does. This is particularly important as it provides income to vendors; however, respondents indicated that given an opportunity they would want to grow *D. steriscus* for their consumption and reducing expenses. Most residents (75%) purchase *D. steriscus* from vendors who move around the suburbs selling the crop. Therefore *D. steriscus* provides employment to low income earners. Some people may not be able to identify the plant in the wild so it is difficult for them to obtain it from the source areas; others simply do not have time to do so due to other commitments. The results are in line with Ahmad and Javed [7] and Hughes [13] who established that early people, vendor, and Hakeem's were more experienced and had more knowledge about underutilized crops.

4.6. Availability of D. steriscus throughout the Year. Dioscorea steriscus is a source of income for vendors who area mostly people from areas surrounding Bindura town. They sell a mean weight of 21.3 kg per trip and the standard deviation is 6.62 kg. The quantity sold is just about what an individual can carry on the head. This also suggests that there are transport bottlenecks for the vendors. The results agree with the assertion by Izquierdo [8] that access to markets is a problem for all rural farmers.

Dioscorea steriscus is available during the dry period from July to November (Table 4(b)). In Zimbabwe this period coincides with the period when people have finished harvesting. This long window of availability implies that people can rely on the crop for at least half a year thus making it a reliable rescue crop. Since *D. steriscus* is available during a longer period it is possible to dry the crop for future use during lean periods.

4.7. Willingness to Grow D. steriscus. Urban dwellers are willing to grow *D. steriscus* for their own consumption; Wald statistic (which is a conservative test of the unique contribution of each predictor) indicates that marital status, education level, and size of family (1.69, 1.45, and 1.44), respectively, are the main contributors to growing of *D. steriscus* in Bindura. The logistic regression indicates that, irrespective of gender of respondent, suburb of residence, size of family, period of stay in Bindura, education level, employment status, and sources of income, respondent will grow *D. steriscus* for use as food supplement. This should significantly improve nutrition of the population since we observed that the plant is highly nutritious especially in terms of energy and mineral components. Although residence (45%) would want to cultivate *D. steriscus,* it is difficult especially taking into consideration the fact that they are urban residences that only have their residential area occupied by the house. However, with the current situation in the country where the local councils allow residence to farm open pieces of land it is possible for some to cultivate this plant.

5. Conclusions and Recommendations

5.1. Conclusion. The majority of respondents (65%) indicated that they eat *D. steriscus*. This was regardless of the socioeconomic characteristics of the respondents except education level. Frequency of use of eating of the crop is also relatively high with 45% of the respondents taking the crop at least once a week. Generally the crop is available on the market from May to December and vendors sell the crop at least once a week carrying just over 20 kg on each trip. *D. steriscus* is high in DM content particularly iron, dietary fiber, and carbohydrates and these are important nutrients required in significant quantities by the human body. There is a significant difference in the consumption of *D. steriscus* in Bindura high density suburbs with respect to education level; $P < 0.05$.

5.2. Recommendations. Since the crop is popular and can be used during lean periods (dry season), there is need to invest resources to develop the crop. At the same time council should provide land that has been designated for periurban farming by the government to residence willing to cultivate this underutilized plant. More research is required in order to establish the nutritional composition of the crop so as to provide information to the skeptical category that comprises those with higher education levels. The plant growth characteristics, habitats, and climatic requirements are all not known for Zimbabwe; plant development institutions like CIMMYT and ICRISAT should partner government in fulfilling this endeavor. There is need to domesticate the crop so that larger quantities of the crop are made available for the benefit of both vendors and the consuming public. This will also help in conserving the plant species. The conditions that favour the growth of the crop can be provided in home gardens.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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