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Miombo Woodland Mushrooms of Commercial Food Value: A Survey of Central Districts of Zimbabwe

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Abstract Wild Miombo woodlands mushrooms are a largely ignored nutrition-boosting food and source of income among rural communities of Southern Africa. A survey was conducted in the Gweru, Kwekwe, Shurugwi and Mvuma districts of Zimbabwe to establish the importance of this natural resource in household poverty reduction.Gathered quantities and sales realized were recorded through structured personal interviews targeting two thirds of gatherers with equal numbers of male and female respondents and one key informant in each site. Results showed that of 14 gathered mushroom species (orders *Cantharellales*, *Amanitales* and *Termitomycetes*) across all sites, five species were of varying commercial value. *Amanita loosii* was the most traded and the only one with available data on sales. Ranked according to their gathered volumes by percent respondents per gathering occasion were *A. loosii* (97.48%), *Termitomyces le-testui* (72.94%) (non-mycorrhizal), *Cantharellus heinemannianus* (62.96%), *Lactarius kabansus* (46.72%) and *C. miomboensis* (37.04%). Average selling prices for *A. loosii* ranged from US$0.10 to US$1.00 per litre (about 600 grammes) across all sites. Average sales per site for a gathering occasion ranged between 20 and 400 litres per vendor across the sites, although up to 800 litres was recorded at Blinkwater for three gatherers. Principal Components Analysis biplots showed Blinkwater and Sebakwe sites had strong associations with high sales volumes and high sales value of *A. loosii*. It was concluded that, *A. loosii*, in particular, contributed to an important food and income source in the studied sites, with some communities having a large potential to raise these incomes beyond their current levels provided gathering and marketing methods were improved.

Keywords: *amanitales, cantharellales, ectomycorrhizal mushrooms, termitomycetes, wild edible mushrooms*

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1. Introduction

The practice of wild foods gathering has been with mankind since time-immemorial. Wild mushroom gathering dates back to 900 BC in China [9]. Gathered foods included fruits, relish of plant leaves, roots, and mushrooms [3]. Around one billion people worldwide are reported to consume gathered foods and three hundred million consumed forest foods as at the beginning of the current millennium [3]. These foods have a significant contribution to dietary enrichment, medicinal and trade value for many communities [9]. Although work has been done to analyze the dietary value of some mushrooms, the extent to which such foods have been included in rural household diets has not been systematically studied among Southern African communities.

Quite a number of wild edible and poisonous mushrooms of the Miombo woodlands have been characterized and documented. At least 21edible mushroom species (including *Termitomyces* and saprobes) and largely in the orders *Russulales*, *Boletales*, *Cantharellales* and *Amanitales* were described [18,19]. In the Tanzanian Miombo woodlands, a total of 57 species were reportedly gathered for food, mainly from the orders *Boletales*, *Cantharellales* and *Amanitales* [2]. The number of gathered mushroom species wasreported for Zimbabwe, Malawi and the Democratic Republic of Congo (DRC) to be 45, 60 and 53 respectively [20]. Outside the Miombo woodlands 9 mushroom species were reported to be consumed in Nigeria [25] and 18 in Nepal [24]. On the whole 1 069 fungal species are known to have been consumed worldwide, including those outside the Miombo vegetation [3]. This picture clearly reveals the mushroom food resource richness worldwide and in the Miombo woodlands in particular. In the Miombo woodlands gathered quantities of mushrooms are still largely undocumented. However, in Malawi rapid depletion of some otherwise valuable Miombo mushrooms resulting from deforestationwas recorded [1], but its extent remains undocumented.Non-mycorrhizal mushroom species also occur among the Miombos. These include *Termitomyces sp.*, which grow on termite mounds, and *Ganoderma sp* which thrive on dead wood logs [18,19,21]. Information on the economic value of these and other species is still scanty.

Mushrooms were reported to be of high nutritional value, particularly as a healthy food [8]. *These researchers found mushroom dry mass* to consist of protein

(25.71- 36.51%), lipid (1.4 – 2.79%), carbohydrate (37.38 – 48.63%), minerals (4.45 – 10.29%) and fibre (3.77 – 11.44%). Similar analyses elsewhere also revealed richness of the commodity in protein, carbohydrate and essential micronutrients [14]. In China, studies showed some five wild mushrooms to have strong anti-hyperglycemic and anti-oxidant value [23].

As a relish, wild mushrooms arecomparable to vegetables in their nutritive value and superior as a protein supplement [8], and [14]. Generally, wild mushrooms were also found to be high in their nutritional valueby other workers [5]. Although science generally ascribes high dietary richness of mushrooms, studies have not been conducted on whether communities realize this value and to what extent they compare this food resource to traditional meat and pulse-based diets.

Annual worldwide wild mushroom trade was reported to run into billions of US dollars [13]. Wild ectomycorrhizal mushrooms (ECMs) are an important source of income for rural communities all over the world [4]. Furthermore, the importance of wild mushroom trade was realised in both developed and developing countries where 1 100 species in wild mushroom were traded [10]. In Zimbabwean Miombo woods wild mushroom trade at a glance was quite conspicuous and popular among urban and rural consumers, in addition to foreigners [10]. A similar situation in Malawi was earlier noted [1]. However, data on quantities traded and realized economic value at household level for Zimbabwe, in particular, is not available.

In Tanzania and Malawi wild mushrooms were found to be sold at roadsides in rural communities [1,2], and via door to door deliveries by vendors selling to urbanites in Malawi [1]. In Zimbabwe much of the sales are conducted on roadsides and open urban markets. Wild mushrooms have thus been destined for small markets as observed in Finland [6]. There is need for deliberate efforts to identify specific marketing practices in use so as to develop policies and methods for improving theirvalue and bring them onto formal, more profitable markets as evident in Mexico [16].

Popularity of different mushrooms differ greatly, with three main genera, namely *Cantharellus*, *Amanita* and *Termitomyces* being traded in Malawi [1] and in Tanzania [2]. Elsewhere outside the Miombo woodlands, *Tricholomataceae*, *Pleurotaceae*, *Polyporaceae* and *Hymenochaetaceae* families were reported to provide important mushrooms in Korea [15], where there was a completely different climate and vegetation.

Mushrooms were found to contribute significantly to rural household incomes in parts of Malawi [1]. Their economic value ranged between US$0.05 to US$0.84 per litre on the worst markets to US$11 - US$30 per litre on the best markets per day in the marketing season. Annual incomes of US$400 to US$900 per gatherer were recorded in Tanzania to range from US$500 to US$650 per season [7,21]. In rural Finland, wild mushrooms were also found to increase household incomes in Mexico [16]. Despite differences of incomes earned from wild mushroom sales across different countries worldwide it can be concluded that there is, indeed, some high value in trade of this commodity, the quantities of which still need research.

Mushroom gathering and economic potential to surrounding communities in Southern Africa is not well documented, save for Malawi [1] and Tanzania [2], [21].In their contribution to global food security, wild edible mushrooms still offer huge room for scientific and social research in the quest to improve livelihoods among the Miombo woodland hinterlands in Zimbabwe and other parts of Southern Africa. Such research needs to be complemented by systematic study and documentation of the gathered mushrooms' commercial and dietary value for Zimbabwean rural communities. Accordingly, the purpose of this study was to identify Miombo mushrooms of community dietary and commercial value, and trade practices employed by Miombo woodland mushroom gatherer-traders in selected study sites of the central districts of Zimbabwe.

2. Materials and Methods

2.1. Study Sites

All sites selected were in the central Midlands Province of Zimbabwe where edible Miombo woodland mushrooms were abundant. Study sites were selected on nomination by local councilors and experienced mushroom vendors in the town/city/population centres. These advised the researchers on which communities traditionally gathered mushrooms annually. One community was selected as the study site within five kilometres of a mushroom-prolific gathering Miombo woodland area. The selected communities had at least 75% of their members being confirmed regular and experienced mushroom gatherers by the key informers.

Study sites were Sebakwe Bridge and Chitepo Ward in Zhombe both in Kwekwe, Lingfield Farm in Gweru, Little Mpali in Shurugwi and Blinkwater in Mvuma. All these sites were located within five kilometres of a major highway where mushroom vending actively took place, except for Chitepo site. The latitude, longitude and distance from the nearest major population centre for each site were varied (Table 1).

Table 1. Grid References and Distance from Nearest City/Town for Each Site

Site	Latitude (^{0}S)	Longitude (^{0}E)	Distance from city/town (kilometres)	Peripheral markets (rural, urban)
Sebakwe	18.851389	29.805011	7	Sebakwe Bridge, OK Market
Chitepo	18.723155	29.264355	65	Mugandani, Zhombe
Lingfield	19.484700	29.887771	3	Regina Mundi, Kudzanayi Bus Terminus
Little Mpali	19.686589	29.931506	4	Bethel Turn-Off, Shurugwi Business Centre
Blinkwater	19.317314	30.515139	4	Spar Supermarket, Mvuma Business Centre

2.2. Research Design

A descriptive survey was conducted using homogeneous purposive sampling [22] of mushroom gatherers in each site. Sub-samples of 75 percent of interviewees were drawn for participation in the survey. The sub-sample sizes were: 60, 22, 40, 38 and 46 for Sebakwe, Lingfield, Chitepo, Little Mpali and Blinkwater respectively, with equal numbers of male and female participants for each sub-sample. A key informant for each site was interviewed in order to confirm mushroom names and other pertinent details. The structured questionnaire was administered through personal interviews.

2.3. Data Collection and Analyses

Data collected were on: types of mushrooms and quantities gathered per gathering occasion, prices charged per litre container, revenues realized per selling event and challenges faced in mushroom gathering and marketing in general.

Data were reduced to percentages of gatherers and traders for each assessed parameter. Principal Components Analysis (PCA) was done for mushroom species numbers sold, sales volumes and sales value using Canoco Version 5.0 (2012) to test each components' association with the selected sites of study. The same analysis was used to establish associations of the gathering and marketing challenges faced by gatherers in each site surveyed.

3. Results

3.1. Mushroom Species Gathered

The most gathered and traded mushroom in each site was *A. loosii*. The non-mycorrhizal mushroom *T. le-testui* was also of great importance in both its gathering and trade across the sites (Table 2).

Table 2. Percentage of Respondents who Gathered Each of the 14 Wild Mushrooms Species Across all 5Sites

Mushroom type		Study site and percentage gatherers observed				
	Local name	Sebakwe	Chitepo	Lingfield	Little Mpali	Blinkwater
Amanita loosii †	nhedzi	98.3	100	100	100	89.1
Lactarius kabansus †	nzeve	46.7	57.5	13.6	65.8	50
Cantharellus heinemannianus †	tsvuketsvuke	88.3	50	31.8	73.7	71
C. miomboensis †	chihombiro	60	20	0	68.4	36.8
****Termitomycesle-testui*** †	dare	88.3	75	40.9	76.3	84.2
****Termitomyces sp***	uzukwe	0	50	9.1	31.6	36.8
Clavulina wisoli	ndebvudzasekuru	35	15	0	13.1	23.7
Lactarius velutissimus	nyakasheche	0	0	0	0	5.3
Boletus sp	dindindi	0	17.5	0	36.8	17.5
Cantharellus sp.	firifiti	0	12.5	0	65.8	39.5
Russulasp.1	madhondowa	0	32.5	0	5.3	10.5
Mackintoshia persica	matifi	0	7.5	0	0	5.3
Lactifluus edulis	nhemayakanda	0	0	0	2.6	15.8
Russula sp.2	chambwe	0	2.5	0	0	18.4

†mushrooms traded across all sites *Non-mycorrhizal mushroom species.

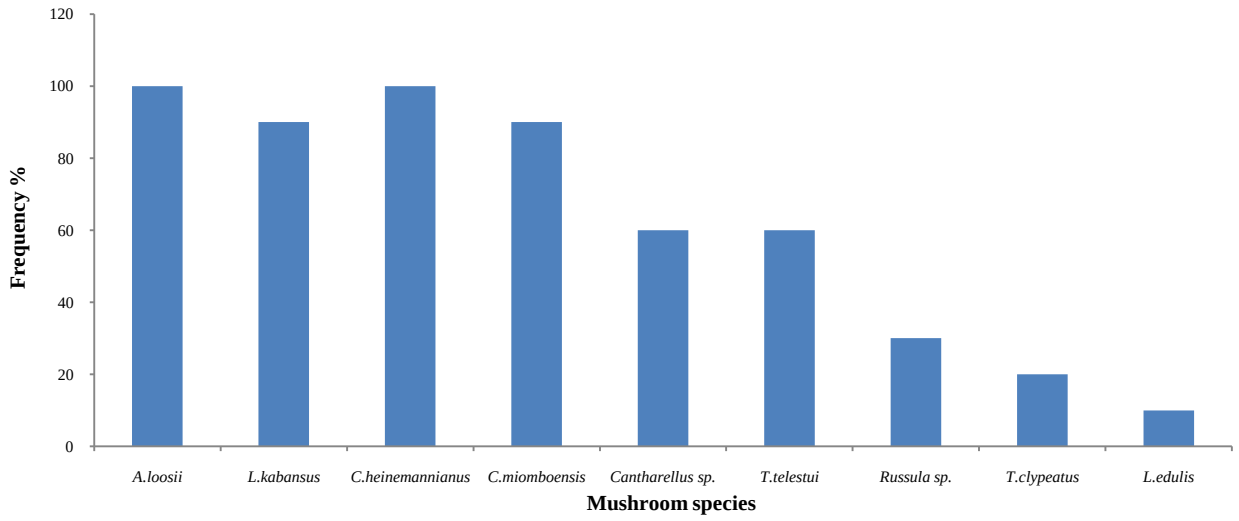

Figure 1. Frequency of peripheral markets adjacent to study sites which sold each mushroom species

Results showed that not all gathered mushrooms were destined for the market. Only nine species both fresh and dried were sold across all sites of which five species were observed to be sold fresh either by the roadside or town stalls. Across all sites, gatherers indicated the priority mushroom with complete gathered volumes and sales data as *A. loosii.*

Market observatory surveys in two selected places (roadside and town stalls) in each study site showed that other species apart from *A. loosii* were also gathered and sold but by vendors in these particular places. All of the peripheral markets sold *A. loosii* and *C. heinemannianus* while a mere 10% sold *L. edulis* (Figure 1).

3.2. Volumes and Value of Sales for *A. loosii*

Prices charged for *A. loosii*across the study sites ranged from US$0.10 to US$1.00 per litre.In contrast, supermarket prices for cultivated mushrooms *Pleurotus* and White button (*Agaricus* sp) ranged from US$6.0 to US$10 per kg (equivalent volume of 1.6 litres when loosely packed in open containers). Volumes of *A. loosii*sold per day varied from 20 litres at Chitepo, up to 120 litres elsewhere, and a high of 400 litres at the Blinkwater site. The highest volumes of *A. loosii* were gathered at Blinkwater while lowest volumes were recorded at Chitepo per gathering occasion. Prices were lowest at Lingfield (Table 3). Mushrooms were sold inone litre dishes where the average mass for *A. loosii* was 680 grammes per litre container.

Table 3. Average Gathered Volumes of *A. loosii* and Prices Charged per Litre for a Gather-sale OccasionAcrossSites

	Site				
	Seba	Chitep	Lingfld	LittleMpa	Blinkwater
Vol. (l)	120	20	60	40	400
Price (US$/l)	1.0	0.5	0.15	1.0	1.0

Average sales values for *A. loosii* for each site on a gather-selling occasion and average selling price for the five sites varied greatly (Figure 2). Blinkwater recorded the highest sales while Chitepo gave the lowest sales while the lowest sales were recorded at Chitepo.

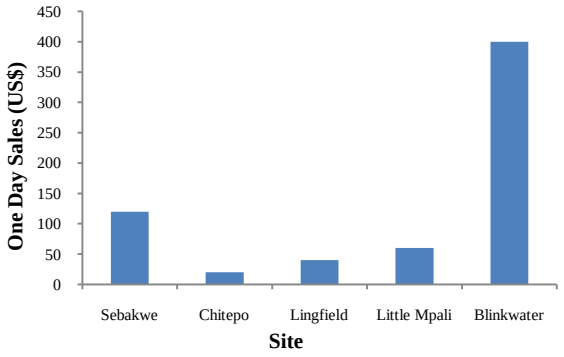

Figure 2. Maximum daily revenue realized by gatherer-vendors for *A. loosii* across the five sites

Thirty two percent of respondents at Sebakwe indicated that their customers were both local (Zimbabwean) and foreign (non-Zimbabwean), where locals were said to purchase in small quantities (maximum 2 litres per customer). There were also indications by 11.7% of respondents at Sebakwe that some customers used the product as pig feed and hence bought in bulk (over 10 litres) but offered lower prices. Three percent of respondents at Sebakwe and five percent at Little Mpali indicated that local customers were either skeptical about genuineness of the commodity or they pretendedly doubted its genuineness in order to negotiate prices downwards.

All respondents who gathered mushrooms, *A. loosii* in particular, across all sites said that the motivation for selling mushrooms was to earn easy and quick money. Therefore they temporarily abandoned their daily chores during mushroom flashes which started in December ending in March, depending on the prevailing rainfall patterns, which occasionally resulted in only one significant flashwhich translated into one gather-sale occasion. At Sebakwe, 62% respondents, 57.5% at Little Mpali, 47.5% at Blinkwater, 10% at Chitepo and 3.3% at Lingfield indicated that income from mushrooms was used to purchase groceries, furniture items, and pay school fees. At Blinkwater, 30% respondents reported they sold mushrooms to truckers which they gathered in teams where truckers in turn transported the commodity for sale at Mbare Musika in Harare. Gatherers from Sebakwe, Chitepo, Lingfield and Little Mpali did not have access to trucking customers and hence they sold in smaller volumes.

3.3. Comparison of Species Diversity, Sales Volumes and Value across Sites

From the Principal Components Analysis (PCA) biplot (Figure 3), it was determined that the Chitepo site was highly associated with highest percentage gatherers of *A. loosii*, Little Mpali with lowest prices and widest range of species gathered while Sebakwe was associated with highest prices of *A. loosii*. Blinkwater was associated with highest mushroom volumes per gathering occasion.

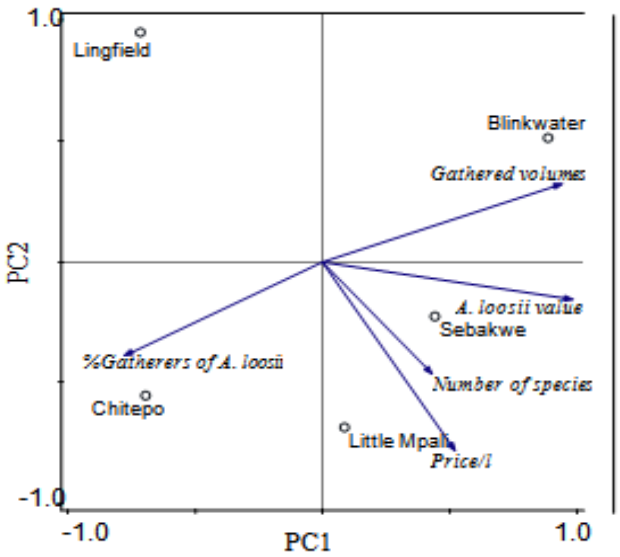

Figure 3. PCA biplot of percentages of respondents who gave *A. loosii* volumes, number of species gathered and incomes realized from *A. loosii* in the five sites

3.4. Gathering and Marketing Selling Opportunities for *A. loosii*

Data on challenges were converted to their inverse percentages and presented as opportunities. These were stated as 'free from other chores', market proximity, prospect to clear sales on same gathering occasion, agility to gather, mushroom abundance, ability to meet gathering timing before dawn, container availability and good choice of gathering place. On the PCA biplot (Figure 4) Blinkwater was positively associated most agile gatherers, highest mushroom abundance, nearest market, gatherers who gathered early, most available gathering containers and most reliable gather sites. Sebakwe was most associated with highest selling prospects and most number of gatherers who were from other chores. Chitepo, Lingfield and Little Mpali werenot associated with any of the parameters.

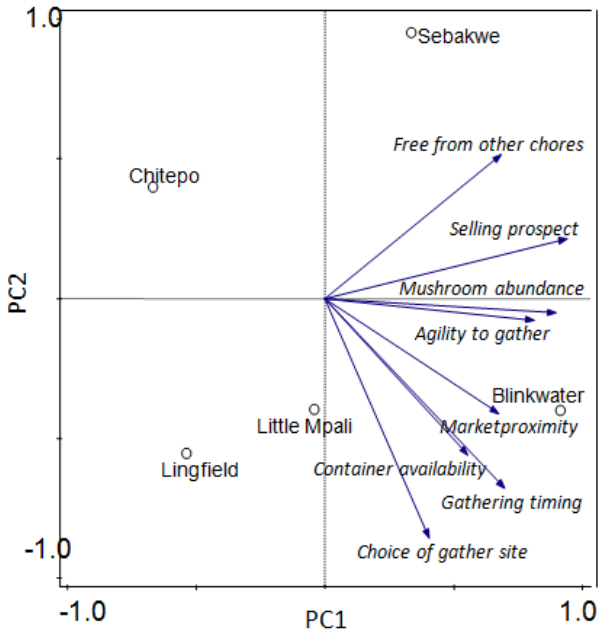

Figure 4. PCA biplot of the opportunities experienced by mushroom gatherers in the five sites

4. Discussion

4.1. Mushroom Species Gathered

This research shows a much smaller diversity of gathered Miombo mushrooms compared to results from similar woodlands in Tanzania [2], Malawi, DRC, Zambia and Zimbabwe [20]. The possible reasons for this difference are the different climatic and soil traits in the studied sites, and possible cultural differences that exist among the communities surveyed. As observed for high mushroom species number in Blinkwater, which had a relatively undisturbed forest on a fenced commercial farm, low mushroom diversity across the other sites is very likely to be caused by deforestation [1].

Although this research revealed 14 mushroom types were gathered for food, the indigenous knowledge appeared incomplete among the gatherers. There is a real possibility that more or less than recorded types were being gathered but due to lack of written records, some types may not fruit regularly either due to their genetic programming or minor dietary value when overwhelmed by the more popular ones in their 'on-years'. This implies that the knowledge focus for such seemingly minor mushroom species during the survey may have faded in the respondents' minds due to their lack of prominence.

In the studied communities same mushroom species could be given different names by different interviewees or different species given the same names by different interviewees[12]. An example is *Boletus*, *Afroboletus* and *Phlebopus* sp. Which were given as 'dindindi' or 'matindindi'.This was especially evident where field identification traits used were different in themselves, for example, some gatherers used 'gathering place' while others used milky latex for identifying *L. kabansus*, which some gave as 'nzeve' while some called it 'nhowa'.

All this is due to the apparent lack of systematic education and written records compiled from confirmatory genetic tests. However, the apparent mix-up of names did not seem to result in any poisoning fatalities. This could be due to the fact that some mushroom types are cooked or preserved in combinations, for example, *Cantharellus heinemannianus*, *L. kabansus* and *Clavulina wisoli*.

4.2. Gathered Volumes

Volumes of gathered mushrooms were found to be highly dependent on the site of mushroom gathering woodlands possibly depending on the inherent variation in climatic conditions and soil types of the different sites. However, other persuasive factors could account for the differences in gathered volumes, including possible differences in mushroom strains and vegetation. In the interviews, respondents also seemed to intimate on related issues affecting volumes gathered for each occasion (Figure 4). These factors seemed to beimportant determinants in the gathering activities studied. Caps of *A. loosii* are larger than of the other species except for *T. le-testui*. It is easier to fill a container with *A. loosii* within a small gathering area than with the smaller and more sparsely growing types like *C. heinemannianus* and *Clavulina wisoli*, which are thus gathered in mixtures. Such small types are likely to be more difficult to remove soil and leaf litter on their caps. While most of the species are more difficult to identify, *L. kabansus* in particular, *A. loosii* has more prominent identification features of colour, shape and slipperiness. Basing on the gathering time before dawn, it is easier to spot *A. loosii* caps than the smaller darker-coloured *L. kabansus* and yellow types such as the *Cantharellales*.

4.3. Wild Mushroom Value and Trade

Although the range of mushroom species gathered was high (14), it appeared *A. loosii* was dominant on the trade scene out of the five species offered for sale as the study revealed. On the other hand, in Mexico, *C. cibarius* was the most gathered and most consumed wild mushroom [11]. The dominance of *A. loosii* was due to its ease of picking, relatively larger abundance and high popularity among customers compared to the minorspecies. However, a wider range was observed to feature on all peripheral

markets studied because all these markets sourced their wares from a wider number of gatherers and that they were in the full-time business of vending mushrooms and other wares.

4.4. Prices, Sales Volumes and Value for *A. loosii*

Seasonal gathered volumes and, hence, sales could not be determined as these were found to be highly dependent on annual variations in climatic conditions, which influenced the number of mushroom flushes in the season. Further to this, gatherers did not keep written records of their activities in this business and hence could not be certain on mushroom income contribution,particularly for the minor mushroom species.

Gathering and selling opportunities varied from site to site as each site had a different vegetation and climate regime. Sites associated with high mushroom volumes, namely, Blinkwater and Sebakwe were also found to be associated with high reported mushroom abundance, high prospects of sales, high agility (youthfulness) of gatherers and freedom from other pressing chores in agriculture. It was observed that these two sites had communities that were more involved in gold panning and casual employment in nearby population centres. None of their time was spent on agricultural activities. Ready markets for these sites were also found to be available, with Sebakwe being located along the busy Harare-Bulawayo highway while Blinkwater had truckers to buy the bulk of gathered wares for sale at the vibrant market of Mbare Musika.

In contrast to Sebakwe and Blinkwater communities, Little Mpali, Chitepo and Lingfield communities were tied up in farming activities, which coincidentally were at peak during the mushroom season. Lingfield was a commercial farm where all adults were farm employees, whereas Little Mpali and Chitepo were communal farming areas, where all adults spent most of their time in agriculture more than in mushroom gathering. Little Mpali was closely associated with low prices of *A. loosii* possibly due to low selling prospects as most people were reported to prefer own gathering, thereby obscuring the maximum sales potential despite the reported high mushroom abundance, a relatively large number of youthful gatherers and proximity to its market.

Compared to prices of commercialized mushroom species, namely white button (*Agaricus sp*) and oyster (*Pleurotus sp*), gathered mushrooms still commanded very low prices (less than one fifth by volume). Hence, there is substantial potential to increase incomes from the volumes observed to be gathered. Skepticism among potential consumers on whether the wild mushrooms presented for sale, particularly where the vendors are neither registered nor have traceable references, continues to keep sales below their potential.

5. Conclusions

This study revealed that the most important ectomycorrhizal mushroom of economic value among communal vending sites studied was *A. loosii.* However, on the basis of gathering frequencies alone, *C. heinemannianus, L. kabansus* and *C. miomboensis*, were also of prominent dietary contribution and potentially high income contribution. Hence, from the incomes realized by the gatherers on sales of *A. loosii* alone, there is substantial potential in community economic benefits from wild Miombo woodland mushroom sales. It is therefore recommended that gathering, handling and marketing methods be developed so as to make the most out of wild mushrooms for the communities dwelling around such productive Miombo woodlands of Zimbabwe.

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Statement of Competing Interests

The authors have no competing interests.

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