



# Towards reduction of postharvest losses in mushroom farming in Ghana: Methods and strategies



## Research article

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#### Abstract

There are about 69,000 known mushroom species of which 2,000 are regarded as edible mushrooms (Chang and Tropics, 1991). Edible mushrooms have been collected and consumed by people for over thousand years ago. Some wild species harvested in Ghana are *Termitomyces spp*, *Volvariella volvacea*, *Coprinus spp*, *Cantherellus aurantiacus* (Obodai, 2001). Edible mushrooms are good sources of vitamin B<sub>2</sub>, niacin and foliate, with contents varying in the ranges 1.8 – 5.1, 31 – 65 and 0.30 – 0.64mg/100g dry weight respectively (Mattila *et al.*, 2001). Harvesting is done by twisting the fruiting bodies from the substrate by hand, leaving no bits of stem behind. The survey was conducted between November and December, 2014 to obtain baseline data on farmers' knowledge on methods of harvesting, postharvest management and ways of reducing postharvest losses of wild mushrooms in the Kpelezo community in the Volta Region of Ghana. Fifty farmers (50) were randomly selected from the community for the survey. From the study, 37% of the farmers suggested that postharvest losses of mushroom can be minimized by digging the soil around the mushrooms before pulling them with hands. 31% of the farmers were of the view that losses can be minimized by handling mushrooms with care and tying them up with threads. 22% of farmers were of the opinion that proper handling of mushrooms after harvesting can reduce losses.

**Keywords:** cultivated mushroom, edible mushroom, postharvest, pests, preservation, wild mushroom

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### Public Interest Statement

A wide range of diseases and pests can cause serious problems in mushroom cultivation, and management of those diseases and pests is a key factor in successful mushroom production (Cha, 2004). Common pests of mushrooms include mites, midges, millipedes and nematodes. They damage the fruiting bodies, attack the mycelium and tunnel through the stalk resulting in yield losses. The taste and nutritional value of fresh mushrooms is usually better than that of conserved mushrooms. Nevertheless, conservation methods are necessary when only part of the harvest can be sold fresh. Canning, brining and drying are the most common techniques, but not all conservation methods are equally suitable for all different types of mushrooms (Oei, 2003; Byung, 2004). Canned oyster mushrooms, for instance, taste horrible except *Pleurotus cystidiosus* and *Pleurotus abalonus*. Contrary, oyster and shiitake mushrooms give off a specific fragrance after drying.

### Introduction

Mushroom is a macrofungus with a distinctive fruiting body, large enough to be seen with the naked eye and to be picked by hand (Chang and Miles, 1992). All mushrooms belong to the kingdom of Fungi, a group very distinct from plants, animals and bacteria (Oei, 2003). They lack chlorophyll hence depend on other organisms for food (Oei, 2003). Most of the cultivated mushrooms belong to the phylum, Basidiomycetes, which produce their spores on basidia while another important group are Ascomycetes, which produce their spores in asci (Oei, 2003; Arés *et al.*, 2007). Mushrooms thrive well at relative humidity level of around 70-80% and moisture level of 50-75%. There are about 69,000 known mushroom species of which 2,000 are regarded as edible mushrooms (Chang and Tropics, 1991). Edible mushrooms have been collected and consumed by people for over thousand years ago. Archaeological record reveals edible mushroom species associated with people living 13,000 years ago in Chile, but it was in China where consumption of wild fungus was first reliably noted several hundred years (Boa, 2004). Some wild species harvested in Ghana are *Termitomyces spp*, *Volvariella volvacea*, *Coprinus spp*, *Cantherellus aurantiacus* (Obodai, 2001). Total commercial mushroom production worldwide has increased more than 21 times in 35 years, from about 350,000 tons in 1965 to about 7.5 million tons in 2000 (Boa, 2004). From 2000 to 2009, global production increased to 67% excluding unofficial production figures emanating from China (Verma, 2013).

Mushrooms are rich in non-starchy carbohydrates, proteins, dietary fibre, minerals, and vitamin-B and are quite low in fat value (Dunkwal *et al.*, 2007). The proteins of mushroom are of high quality and rich in various essential amino acids. With regard to their good nutritional and high digestibility values mushrooms are gaining importance in today's healthy diet (Dunkwal *et al.*, 2007). However, in the countryside and forest regions, several species of wild mushrooms are collected for consumption. During the onset of the rainy

season, when mushrooms are abundant, most people in the rural areas collect them from the forests for home consumption and sell for extra income (Apetorgbor *et al.*, 2005).

Despite its importance, the figures for Ghana's mushroom production over the years were not known even after the introduction of the National Mushroom Development Project in 1990 (Sawyer, 2000) to produce exotic mushrooms such as *Pleurotus* spp. The introduction only brought about small-scale mushroom farms mostly for urban unemployed while the technologies developed for the straw mushroom, *Volvariella volvacea*, had not been adequately transferred to the rural communities (Apetorgbor *et al.*, 2005). Due to its perishable nature, mushrooms are susceptible to a wide range of pests and diseases (Cha, 2004). Common pests of mushrooms include mites, midges, millipedes and nematodes. Some of these pests damage the fruiting bodies and attack the mycelium in the soil while others like nematode tunnel through the stalk (Oei, 2003). Other factors such as dehydration and enzymatic browning affect mushroom quality.

## Literature Review

### Harvesting and Processing of Mushrooms

Mushrooms form primordia (hyphal knots) within 10 days after spawning and are able to produce ready-to-pick fruit bodies within 15 days at an optimum temperature of about 23° – 28°C (Oei, 2003). The stage at picking mushrooms depends on the consumer preference and the highest profitability. For oyster mushrooms, picking should be done when the outer margin of the fruiting bodies has only just rolled inwards, on the verge of becoming horizontal. Contrary, *Termitomyces* are picked when the veils are yet to open. In this way, the prize is higher and the infestation by nematode is reduced. Ideally, mushrooms should be picked with minimum handling since they are easily damaged (Oei, 2003). Harvesting is done by twisting the fruiting bodies from the substrate by hand, leaving no bits of stem behind. Oyster mushroom, for instance, can either be harvested in bundles or as single fruiting bodies. However, some species such as *Termitomyces* can only be harvested singly. After harvesting, mushrooms are either sold fresh or processed into different forms in a pack. Under ideal conditions, packed mushrooms for the fresh market are covered with a plastic film and cooled rapidly after harvesting (Oei, 2003). The plastic film provides good protection from water loss, as long as the storage temperature is more or less constant.

The taste and nutritional value of fresh mushrooms is usually better than that of conserved mushrooms. Nevertheless, conservation methods are necessary when only part of the harvest can be sold fresh. Canning, brining and drying are the most common techniques, but not all conservation methods are equally suitable for all different types of mushrooms (Oei, 2003; Byung, 2004). Canned oyster mushrooms, for instance, taste horrible except *Pleurotus cystidiosus* and *Pleurotus abalonus*. Contrary, oyster and shiitake mushrooms give off a specific fragrance after drying. The selection of the method for

processing mushrooms depends, among other things, on the ultimate use of the products as well as on the storage period envisaged (Bernaś *et al.*, 2006).

### **Drying**

The oldest and simplest method of processing mushrooms is drying (Bernaś *et al.*, 2006). Drying preserves the mushrooms by removing enough water to inactivate the enzymes and microorganisms (Byung, 2004). Fresh mushroom contains about 90% water and exposure of the product to temperatures of 55-70°C for a number of hours to a final moisture content of 10% and below ensures that it does not deteriorate easily (Rai and Arumuganathan, 2008; Byung, 2004). However, longer drying at low temperatures is safer than faster drying on high heat, as the mushrooms could become toasted at high temperatures (Oei, 1996). According to Oei (1996) drying of mushrooms could be artificial or sun drying. The disadvantages of sun drying are that: a) sand and dust decrease the quality and value of the product; b) there is an infestation by insect thereby making the product unsafe to eat. It is however recommended to spread the mushrooms on a platform above the ground (Oei, 1996). Drying whether artificial or natural has significant effect on the colour of the dried product due to the exposure to temperature, moisture of the mushroom and humidity of the air (Rai and Arumuganathan, 2008).

### **Freezing**

Freezing is the best processing method for preserving the natural taste and aroma of mushrooms (Lobaszewski and Paczynska, 1990). According to Rai and Arumuganathan (2008) in order to preserve mushroom for about a year or more, the product must be frozen at a temperature of -18°C and below. At this temperature, the growth of microorganisms, respiration and moisture loss from the mushrooms is minimized. In general, the nutritive value of frozen products exceeds that of sterilized food (Bernaś *et al.*, 2006).

### **Canning**

Canning is by far the most common process used for preserving mushrooms (Byung, 2004). This technique can preserve mushrooms for longer periods up to a year or more (Rai and Arumuganathan, 2008). The process can be divided into various unit operations namely cleaning, blanching, filling, sterilization, cooling, labeling and packaging (Rai and Arumuganathan, 2008; Byung, 2004). Mushrooms must be canned in a pressure canner for the correct time and pressure to ensure their safety otherwise they may contain the deadly botulism toxin (Schafer, 2010). Pre-processing of mushrooms before sterilization plays an important role in maintaining good quality of canned products (Bernaś *et al.*, 2006). The measures most frequently applied in preliminary processing are soaking and blanching in

solutions preventing the darkening of the products (Rodrigo *et al.*, 1999). Jaworska *et al.* (2003) reported that the addition of brine in the production of sterilized mushrooms decreases the dry matter by 26 – 28%, total sugars by 12 – 29%, total acids by 29 – 36% and total nitrogen by 24 – 29% as compared to raw material after blanching or after soaking followed by blanching. Galoburda *et al.* (2015) opined that blanching mushrooms at high temperature (100°C) denatures protein. However, Vetter (2003) reported that this method of processing does not significantly affect the content of protein or fats in the mushroom but decreases the level of dry matter and ash and some mineral component such as potassium, phosphorus, magnesium and at the same time increases the content of sodium, calcium and iron. It is worth noting that the nutritional composition of any processed product depends on the quality of the raw material used in the production (Bernaś *et al.*, 2006).

### **Pickling**

Pickling mushrooms is a valuable processing method: it involves lactic bacteria, which have a beneficial effect on the human organism and impart a pleasant aroma and taste to the pickled food (Bernaś *et al.*, 2006). Pickling is a long-term preservation of mushrooms in an economically viable way. The product produced after pickling is called pickle. These pickles are good appetizers and they add palatability to the meal (Rai and Arumuganathan, 2008). Mushrooms for pickling are blanched or fried in oil until they become brown depending upon taste preference. Various condiments are ground or fried in oil separately and added to the mushroom after which the contents are mixed and cooked slightly for few minutes. The mixture is allowed to cool and fill in jars. Vinegar is added for taste and longer storage and the container is topped up with oil (Rai and Arumuganathan, 2008).

### **Methodology**

#### **Survey to assess farmers' methods of reducing postharvest losses of wild mushrooms in the Kpelezo community in the Volta Region of Ghana**

The survey was conducted between November and December, 2014 to obtain baseline data on farmers' knowledge on methods of harvesting, postharvest management and ways of reducing postharvest losses of wild mushrooms in the Kpelezo community in the Volta Region of Ghana. Fifty farmers (50) were randomly selected from the community for the survey. Pre-tested semi-structured questionnaires were read to the farmers by trained enumerators and their responses recorded.

**Findings/Results**

**Farmers’ methods of harvesting wild mushroom, postharvest management and ways of reducing postharvest losses of wild mushrooms**

The questionnaire was administered to mushroom farmers in the Kpelezo community in the Volta Region to obtain baseline information on farmers’ method of harvesting wild mushrooms, postharvest management and ways of reducing postharvest losses of wild mushrooms. The data obtained from the survey are shown below.

**General background of wild mushroom collectors**

Greater number of wild mushrooms collectors in the Kpelezo community in the Volta Region were males (54%) and (46%) were females (Table 4.1). Their main occupation was farming (54%), students (26%), artisans (12%), traders (6%) and animal rearers (2%). For secondary occupation, 76% are into wild mushrooms harvesting, 8% rear animals and harvest wild mushroom, 6% are petty traders, another 6% refine palm oil, 2% are into security and 2% weave baskets (Table 1).

Table 1: Demographic characteristics

Characteristics	Category	Percentage value (%)
Sex	Female	46.0
	Male	54.0
Main occupation	Farming	54.0
	Students	26.0
Artisans		12.0
	Animal rearing	2.0
	Business/trading	6.0
Secondary occupation	Petty trading	6.0
	Harvesting wild mushroom	76.0
	Palm oil refinery	6.0
	Animal rearing & harvesting mushroom	8.0
	Security	2.0
	Basket weaving	2.0

**Method of harvesting wild mushroom**

Sixty-six percent (66%) of mushroom farmers harvest wild mushrooms when the veil was not opened, 32% harvest when the veil was about to open and 2% harvest when the veil was opened. Ninety percent (90%) of farmers harvest mushrooms in the morning and 10% harvest in the afternoon. Eighty-seven percent (87%) harvest mushrooms by pulling them with hand and 14% by digging around them with cutlass before pulling them with hands

(Table 1.1).

Table 1.1: Harvesting of wild mushrooms

Characteristics	Category	Percentage value (%)
Ideal stage for harvesting	When the veil has not open	66.0
	When the veil is about to open	32.0
	When the veil has open	2.0
Ideal time for harvesting	Early in the morning	90.0
	Afternoon	10.0
How mushrooms are harvested	Pulling them with hands	86.0
	Digging around them with cutlass & pulling	14.0
Amount of mushroom collected per day	2.0 kg	2.0
	3.0 kg	30.0
	4.0kg	26.0
	5.5 kg or more	42.0

**Postharvest management of wild mushroom**

Forty-six percent (46%) of farmers kept harvested wild mushrooms in open bowls from the farm to their houses. Thirty-four percent (34%) kept them in covered bowl, 12% in tied sacks and 8% tied them together and held them with hands. None of the farmers pre-treated mushrooms before sale. All farmers packaged fresh mushrooms by tying them into bunches with threads and displayed them at the roadside. Fresh mushrooms that were not sold during the day were treated differently by farmers. Fifty-two percent (52%) of the farmers baked and sun dried fresh mushrooms that were unsold. Thirty-two percent (32%) of them dip mushrooms in salt solution before drying. Furthermore, 12% of them grilled the mushrooms while 2% sun dried them. Two percent (2%) of the farmers steamed the unsold mushrooms (Table 1.3).

Table 1.3: Postharvest handling of wild mushrooms

<b>Characteristics</b>	<b>Category</b>	<b>Percentage value (%)</b>
<b>Mushroom handling after harvest</b>	Kept in an open bowl	46.0
	Kept in a bowl and covered	34.0
	Tied with thread	8.0
	Tied and kept in a sack	12.0
<b>Handling of mushroom when unsold</b>	Baking and sun drying them	52.0
	Dipping in salt soln. & drying them	32.0
	Grilling them	16.0
<b>Volume of mushroom sold daily</b>	1.0 kg	6.0
	2.0 kg	24.0
	3.0 kg	42.0
	4.0 kg	24.0
	5.0 kg or more	4.0
<b>Major causes of loss in mushroom</b>	Pest attack	98.0
	Disease attack	2.0
<b>Reduction of cap/ stalk loss</b>	Holding stalk and gently pulling	10.0
	Digging soil around and pulling them	37.0
	Proper handling mushroom	22.0
	Handling with care and tying them	31.0
<b>Ways to minimize loss in mushroom harvested</b>	Grilling and sun drying	30.0
	Keeping in refrigerator	6.0
	Baking and sun drying	46.0
	Soaking in salt soln. & sun drying	10.0
	Dipping in brine soln. & sun drying	8.0



### **Ways of reducing postharvest losses of wild mushrooms**

It was observed that collectors/farmers sold only about 60% of mushrooms collected per day (Table 1.3). 98% of postharvest losses of wild mushrooms were observed to be caused by pests and the remaining 2% by diseases. 37% of the farmers suggested that postharvest losses of mushroom can be minimized by digging the soil around the mushrooms before pulling them with hands. 31% of the farmers were of the view that losses can be minimized by handling mushrooms with care and tying them up with threads. 22% of farmers were of the opinion that proper handling of mushrooms after harvesting can reduce losses. However, 10% of the farmers suggested holding the stalk and gently pulling the mushrooms to prevent losses (Table 1.3).

### **Discussion**

Kpelezo is predominantly a farming community in the Volta Region of Ghana. The majority of the farmers are male with female forming the minority. These statistics translated in more males engaging in wild mushrooms harvesting than females. Generally, in Ghanaian traditional settings, women engage more in household chores than men. The majority of farmers harvested mushrooms when the veils are not opened. They claimed, mushrooms harvested this way are more prized and less susceptible to diseases and pests attack. Santosh *et al.* (2014) and Oei (2003) stated that mushroom harvested with veil yet to open are more expensive than those with opened veil. Wild mushrooms collectors are ignorant that continuous exposure of harvested mushrooms to air could lead to contamination, pests and diseases attack which will eventually result in the deterioration of the product. Oei (2003) proposed that fresh mushroom should be handled with minimal touch and exposure otherwise lead to postharvest contamination of the product. Mushrooms are harvested early morning to enable sales to customers. Harvesting of the mushroom was done by holding the stalk and gently pulling it which enabled all the parts of the mushrooms to be harvested intact and prevent bruise. Oei (2003) reported that mushrooms should be harvested by gently pulling them from the soil as bruised mushroom hastened spoilage. However, in compacted soil, farmers dug soil around the mushrooms before pulling them to prevent cap and stalk from breaking. Mushrooms harvested with broken stalk and cap are less prized and susceptible to microbial attack (Santosh *et al.*, 2014). Most farmers believed that pretreating fresh mushrooms with water before sale could increase their rate of deterioration. They explained that the mushrooms absorb water and if they are not sold early they deteriorate. Fresh mushrooms harvested by farmers were not packaged in any form before they were sold to consumers. Rather the mushrooms were tied with threads and displayed at the roadside. This practice resulted in multiple handling of the mushroom by sellers and buyers. Oei (2003) proposed that mushrooms should be harvested with minimum touch and handling otherwise they are easily contaminated. Mushrooms that are

not sold were processed by farmers in different ways. Baking and sun drying are the most common processing techniques used by farmers. But the appearance of some of the farmers' samples showed that proper procedures for baking and sun drying were not followed. The higher postharvest loss values of fresh mushrooms observed could be as a result of improper and untimely harvesting as well as mishandling, pest and disease attack of the mushrooms (Santosh *et al.*, 2014).

**Conclusion**

It can be concluded from the findings of the study that mishandling, untimely harvesting and improper harvesting methods of wild mushrooms reduce its market value and provide medium for pests and diseases attack.

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