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POSTHARVEST LOSSES IN OYSTER MUSHROOM (*Agaricus ostreatus*) PRODUCED IN THE HO MUNICIPALITY OF THE VOLTA REGION OF GHANA

BY JOHN YAO AFETSU JUNE, 2014

POSTHARVEST LOSSES IN OYSTER MUSHROOM (*Agaricus ostreatus*)

PRODUCED IN THE HO MUNICIPALITY OF THE VOLTA REGION OF GHANA

A THESIS SUBMITTED TO THE SCHOOL OF RESARCH AND GRADUATE STUDIES, KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF

MASTER OF PHILOSOPHY

(MPhil. POSTHARVEST TECHNOLOGY) DEGREE

BY JOHN YAO AFETSU JUNE, 2014

DECLARATION

I hereby declare that except for specific references which have been duly acknowledged, this project is the result of my own research and it has not been submitted either in part or whole for any other degree elsewhere.

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DEDICATION

This thesis is dedicated to Almighty God for providing me with good health, courage, determination and above all protection. To my beloved wife, Mrs. Vera Elorm Afetsu and to my dearest son Benedict Klenam Afetsu for their prayers, patience and encouragement while I studied in the University.

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ABSTRACT

The study was carried out in the Ho Municipality of the Volta Region of Ghana to assess postharvest losses during oyster mushroom production in the Municipality. Simple random sampling was used to select the producers, marketers and consumers for the interview. Data gathered was analyzed using Statistical Package for Social Science. Linear regression analysis (version 9.0) was used in estimating the major contributing factors to postharvest losses in oyster mushroom production at the producers, marketers and consumers levels. In a laboratory work, one hundred and eighty (180) pieces of freshly harvested mushrooms uniform in size and shape were used. A 3x2x2 factorial experiment established in a Completely Randomized Design (CRD) and treatments were replicated three times. The factors consisted of three different packaging periods (0 hour, 12 hours and 24 hours), two different packaging materials (perforated polythene bags and opened transparent plastic bowls) and two storage environments (refrigerator and room temperature). Each sample was weighed daily with electronic weighing balance, in grams, to determine weight loss. Data gathered were analyzed using GraphPad Prism (version 4.0). Post-hoc Tukey test was conducted on all computed weight losses for all time-dependent treatments to identify any true or significant interactions and possible significant differences between treatments. The survey revealed that majority (40%) of the producers had between 1001-1500 oyster mushrooms composted bags in their production houses and majority (43.3%) of them produced between 41-50kg mushrooms per week. Majority (42.9%) of the marketers sold between 41-45kg mushrooms per week while majority (44.3%) of the consumers consumed about 3-4kg mushroom per week. The level of postharvest losses of oyster mushroom from producers, markers and consumers fell within 40-60% range. The regression analysis revealed that time of harvesting of the mushrooms, number of years of experience of marketing the mushrooms and storage methods were the major contributing factors or causes to postharvest losses of oyster mushrooms in the Ho Municipality. Other factors included high moisture content of mushrooms, postharvest changes, poor storage technology, exposure to heat, inadequate storage facilities, texture changes, brown discolouration and dehydration. During the storage period, weight loss and shelf life were observed. The laboratory studies revealed that oyster mushroom samples that were kept at room temperature lost more of their weights than replicates that had been stored in a refrigerator at 2-3^{0}C with 8-10% relative humidity. Oyster mushroom samples that had been packaged into perforated polythene bags and stored in a refrigerator at 2-3^{0}C had longer shelf-lives than oyster mushroom samples kept in room (average temperature 30^{0}C with 61% relative humidity). The grey colour of the oyster mushrooms changed to orange colour and felt soft in texture for mushrooms packaged into perforated polythene bags and but had firm texture for samples packaged into opened transparent plastic bowls and stored in a refrigerator at 2-3^{0}C (8- 9 days). However, samples that were packaged into perforated polythene bags and opened transparent plastic bowls but stored at an average room temperature of 30^{0}C showed orange colour with dark spots and felt soft in texture 2-5days respectively. Packaging into perforated polythene bags immediately after harvest and stored in a refrigerator at 2-3^{0}C with 8-10% relative humidity had longer shelf life of 8 days. Samples packaged 12 hours after harvest into perforated polythene bags and kept at room temperature of 30^{0}C with 61% relative humidity had 3 days shelf life while samples packaged 24 hours after harvest into perforated polythene bags and kept at room temperature had 2 days shelf life. It is recommended that harvesting of mushroom should be done in the morning, packaged immediately after harvesting and stored under cool conditions.

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1.0 INTRODUCTION

Oyster mushroom (*Pleurotus ostreatus*) is an edible mushroom of the kingdom *Mycetae* and belongs to the family *Agaricaceae*. It has a distinctive oyster like flavour when cooked. The oyster mushroom grows from 5-10cm tall and has irregular lobed orange, yellow or grey cap (Stevenson and Lentz, 2009).

Man has been consuming mushrooms as food, medicine and even as intoxicant since time immemorial by collecting them from the wild. The oyster mushroom has been identified as one of the best mushrooms in the world because of its nutritional values and medicinal contents. Generally, mushrooms are richer than most vegetables in some vitamins such as thiamine (vitamin B_1), riboflavin (vitamin B_2), niacin (vitamin B_{12}), ascorbic acid (vitamin C) and contain a lot of minerals. They have low calorific value, high protein with no starch and sugars and are called the diabetics delight (Rai and Arumuganathan, 2008).

Mushrooms are cultivated commercially in caves, dark cellars or specially constructed mushroom houses in which the proper humidity and temperature are maintained. They are grown in beds consisting of mixture of rotted manure and chemically treated straw, over which layer of soil is spread. The vegetative portion of the fungus known as the mycelium or spawn is used for planting the beds (Stevenson and Lentz, 2009).

In Ghana, including farmers in the Ho Municipality, mushroom farming provides the most economical way to make use of agricultural land and about 5000 to 7000 farmers cultivate mushrooms (Bempah, 2011). According to Sawyerr (1991), in Ghana, mushrooms serve as a tasty meat-substitute and as a vegetable. However, it is not freely available particularly due to its perishable nature which limits the storage life to a couple of days. Physiological disorders are the main causes of postharvest losses of mushrooms. These disorders are mainly caused by slow handling of the products which enhance opening and darkening of the gills, wilting of the entire structure and brown discolouration of the cap and stem (Jayathunge and Illeperuma, 2004).

The shelf life of fresh mushrooms may also be limited by bacterial spoilage or enzymatic browning depending on conditions at harvest and on handling and storage conditions. Washing mushrooms to remove adhering compost produces an attractive product for fresh market but may accelerate browning, increase development of purple blotches and also predispose mushrooms to spoilage by *Pseudomonas tolaasi* and other bacteria as a consequence of mechanical injury to the mushroom surface and water absorption that results in high internal humidity. This defect is described as "brown" or "bacterial" blotch (Sapers *et al.,* 2001).

In 2011, the Ghana Agricultural Workers Union of Trade Congress (GAWU TUC) observed that 30% of what farmers produced never reach consumers for whom it is intended. This is due to the activities of pathogens, bad postharvest operations and environmental factors which are the causes of the massive postharvest losses in Ghana.

Mushrooms have very short shelf life and therefore cannot be stored or transported for more than 24 hours at the ambient conditions and the shelf life is limited to a few days under normal refrigeration conditions which may contribute to postharvest losses and serve as a constraint on distribution and marketing of fresh mushrooms (Sapers *et al.*, 2001; Rai and Arumuganathan, 2008).

Although, oyster mushroom is produced in the Ho municipality, there is little or no information on losses after harvest on the farm, during postharvest handling, storage, marketing, distribution and consumption.

The objective of the study was, therefore, to assess the postharvest losses in oyster mushroom produced in the Ho municipality and specifically to:

i. assess the level of production, marketing and consumption of oyster mushrooms in the Ho Municipality; ii. determine the level of postharvest losses encountered by the producers, marketers and consumers in the Ho Municipality; iii. identify factors that contribute to the losses at the various levels; and iv. determine ways of reducing postharvest losses in mushrooms.

2.0 LITERATURE REVIEW 2.1 HISTORICAL BACKGROUND OF MUSHROOM PRODUCTION AND

CONSUMPTION

Mushroom was first cultivated in 600 A.D with wood ear mushroom. Later, the white button mushroom (*Agaricus bisporus*) cultivation started in around 1650 A.D in France. The cultivation rapidly spread after the Second World War when reliable spawn became commonly available in many countries (Oei, 1991).

Mushroom growing is but one activity in a complete system of agriculture. In mushroom cultivation, agricultural or industrial waste is transformed into soil conditioner. Mushrooms have a high added value in comparison to other crops. They may be exported or consumed within the community where they are produced. Mushroom production is a difficult task involving many steps, from selecting a suitable technique and strain to spawn manufacturing, growing the crop and marketing the final product. Therefore, the activities of mushroom production are undertaken mostly by active and dedicated people (Oei, 1991).

The basis of mushroom cultivation is the breakdown of cellulose. The cell wall structure of virtually all plants is a fibrous structure composed of cellulose and hemicellulose, surrounded by a structural compound called lignin. The lignin wraps around the cellulose fibres like plastic wrap. This makes for a very strong structure, allowing a tree to stand upright for hundreds of years. The cellulose and hemicellulose are made of sugars which are great sources of food, but these are protected by the lignin wrapping, which is a very stable compound and difficult to breakdown. Only a few organisms can breakdown the lignin and utilize it as a food source, thus exposing the underlying cellulose and hemicellulose for food use by other organisms. The best known and most effective of these lignin-breakdown organisms are known as the white rot fungi, of which the Oyster mushrooms are the prime examples. Oyster mushrooms are a closely related species complex, comprised of many species within the genera *Hypsyzygus* and *Pleurotus*. Many different species of Oyster mushrooms have evolved in different locations around the world, and have become more or less specialized in degrading different raw material cellulose sources at different temperatures, oxygen and light levels (Sawyerr, 1991).

According to Royse (2003), total production worldwide has increased more than 18 fold. From 2001 to 2002, the United States produced 393,197metric tonnes of mushrooms (about 7% of the total world supply). Oyster mushrooms accounted for 14.2 % (875,600 tonnes) of the total world production (6,161,000 tonnes) of edible mushrooms in 1997.

Mycophagy the act of consuming mushrooms dates to ancient times. Edible mushroom species have been found in association with 13,000 year old ruins in Chile, but the first reliable evidence of mushroom consumption dates to several hundred years BC in China. The Chinese value mushrooms for medicinal properties as well as for food. Ancient Romans and Greeks ate mushrooms, particularly the upper class. The Roman Caesars would have a food taster taste the mushrooms before the Caesar to make sure they were safe. Many cultures around the world have either used or continue to use psilocybin mushrooms for spiritual purposes as well as medicinal mushrooms in folk medicine (Wikipedia, 2011).

Consumption of mushroom has been on the increase in the United States over decades. Typically used as a vegetable, per capita consumption of this cultivated fungus crop has quadrupled since 1965. Per capita use of all mushrooms totalled about 3.94 pounds (0.79kg) in 2001 compared with about 0.69 pounds (0.31kg) in

1965. Fresh market consumption was 742 million pounds (3.36868x10^{8}kg) in 2001 - 2002 (Gary *et al*., 2003). In Ghana, mushroom is consumed as a tasty meat-substitute and as ingredient in soup and stew. The consumption is about a kilogram in Wa in the Upper West region (Bempah, 2011).

2.2 SCIENTIFIC CLASSIFICATION OF MUSHROOMS

Mushrooms make up the family Agaricaceae. The species usually grown commercially is classified as *Agaricus bisporus,* the field or garden mushroom as *Agaricus campestris.* The chanterelle is classified as *Cantherellus cibarius.* Pore mushrooms make up the genus *Boletus.* The king boletus is classified as *Boletus edulis,* the oyster mushroom as *Pleurotus ostreatus,* the sulfur mushroom as *Polyporus sulfurreus,* and the shaggy-mane as *Coprinus comatus.* Giant puffballs belong to the genus *Calvatia* and other puffballs make up the genera *Lycoperdon* and *Scleroderma.* The true morel is classified as *Morchella esculenta.* False morels belong to the genus *Gyromitra.* The Perigord truffle is classified as *Tuber melanosporum.* Amanitas make up the genus *Amanita.* The fly amanita is classified as *Amanita muscaria,* the death cup as *Amanita phalloides,* and Caesar‟s amanita as *Amanita caesarea.* The jack-o-lantern is classified as *Clitocybe illudens,* the shortstem giant clitocybe as *Clitocybe gigantea,* Satan‟s mushroom as *Boletus satana,* and the emetic mushroom as *Russula emetica* (Stevenson and Lentz, 2009).

2.3 LEVEL OF WORLD PRODUCTION OF MUSHROOMS

According to Royse (2003), total mushroom production worldwide had increased more than 18-fold in the last 32 years, from about 350,000 metric tonnes in 1965 to about 6,160,800 metric tonnes in 1997. The bulk of that increase had occurred during the last 15years. A considerable shift has occurred in the composite of genera that constitute the mushroom supply. During the 1979 production year, the button mushroom, *Agaricus bisporus*, accounted for over 70% of the world‟s supply. By 1997, only 32% of world production was *Agaricus bisporus*. The People‟s Republic of China is the major producer of edible mushrooms, producing about 3,918,300 tonnes each year (about 64% of the world‟s total). China also produces more than 85% of oyster mushrooms (*Pleurotus* spp.) grown worldwide.

The total production includes all fresh market and processing sales together with amount harvested but not sold (shrinkage and dumped, etc.). Average oyster mushroom output per farm increased 113kg (18.3%) per week, from 617kg in 2001 to 730kg in 2002. The production of oyster mushrooms (*Pleurotus* spp.) in the United States had increased at an annual rate of 14% from 881214kg in 1996 to 1936310kg in 2002. This increase reflects an international trend toward increased production of this crop. Oyster mushrooms accounted for 14.2% (875,600 tonnes) of the total world production (6,161,000 tonnes) of edible mushrooms in 1997. The increase in United States production is due to increased consumer demand and the relatively high compensation growers receive for the product (Royse 2003).

Royse (2003) reported that according to the United States Department of Agriculture, farmers received an average of $2.00 per kg for fresh oyster mushrooms while growers of *A. bisporus* received an average of $1.07 per kg for fresh product in the 2001–2002 growing season. The higher price received for fresh oyster mushroom is due to the less-developed and less-reliable technology available to growers for cultivating these species.

In Ghana, Bempah (2011) reported that BemCom Youth Association of Techiman in the Brong Ahafo region raises about 3,700 to 4,500 oyster mushroom composted bags in a week and sells 50kg a day. This is due to availability of electricity and enough water pressure being used to spray the compost bags. According to Apetorgbor *et al*. (2005), in southern Ghana, mushrooms are packaged and sold on weight or bundle basis. Growers of *V. volvacea* produced 5 to 10kg per week, and sold them at GH¢ 3 per kg to customers and *Pleurotus sajor-caju* is sold at GH¢3 per kg and growers produced about 5-50kg per week.

2.4 MARKET POTENTIAL AND LEVEL OF MARKETING OF MUSHROOMS

Mushrooms are delicacy with definite food value. They have acquired commercial status almost all over the world due to their nature of palatability. Mushroom dish is a common item in most big hotels (Bhupinder and Ibitwar, 2007). There are considerable variations in taste and appearance. Marketing potential of dried oyster mushrooms is limited, though the taste becomes stronger after drying. Prices fluctuate, following demand and supply (Oei, 1991).

Consumer demand for ready - to use foods has rapidly increased in recent years. Pizza and pie producing companies have a high demand for sliced mushrooms and supermarkets are selling an increasing number of small packs of sliced fresh mushrooms. The mushroom industry supplies about 5 to 25% of its fresh output as slices (Brennan and Gormley, 1998). Over the 1999-2001 periods, mushroom growers sold an average of 859 million pounds which is 3.89986 x 10^8 kg (Gary *et al.*, 2003).

The value of the 2001-2002 specialty mushroom crops in the United States amounted to $37 million, down 12% from the 2000–2001 seasons. Sales volume of oyster mushrooms, at 4.03 million pounds, was up 11% from the 2000–2001 seasons, with a total of 51 growers producing 1.94 x 10^6 kg of the mushrooms in the 2001–2002 seasons (Royse, 2003). Individual mushroom farmers in Ghana are making from GH¢4.00 to GH¢20.00 or more a day and selling about 10kg a week (Bempah, 2011).

Women are experts in the use, processing and marketing of vegetables including mushrooms. This is because, these are essential resources to sustain the family and ensure good health of the household. Business of selling is an economic venture for people, especially women having little capital, limited access to land and working under labour constraints. The incomes derive from this enterprise contribute significantly to food security at the household level and enable women to attain a degree of financial independence within the family budget (Ninfaa, 2011).

According to Fialor (2011), marketing of commodities including mushrooms is more than just selling. There are several functions which the market system performs. Some of these functions are storage, packaging, distribution, risk bearing, standardization and market intelligence. Agyei *et al*. (1993) observed that marketing of produce including mushrooms constitutes all the processes, facilities and services involved in putting the goods and services into suitable or acceptable forms for the benefit of both the seller and consumer. These activities are strenuous and therefore require much energy and dedication.

2.5 IMPORTANCE OF GROWING MUSHROOM

Mushroom farming provides the most economical way to make use of agricultural land. The production does not need arable land. Agricultural waste is converted into fertilizers and soil conditioner. It is an income generating activity and provides an extra source of protein, valuable vitamins and minerals for man (Oei, 1991).

2.6 NUTRITIONAL IMPORTANCE OF MUSHROOMS

2.6.1. Protein Content

Dry mushrooms on the average contains between 19-40% high quality proteins with all the nine essential amino acids required for good human health. Lysine is the most abundant essential amino acid in mushroom (Sawyerr, 1991). According to Bempah (2011), oyster mushrooms contain about 10-30% protein.

2.6.2 Fat Content

The fat content of mushroom is low (1-8% dry weight) and consists mostly of unsaturated fatty acids, which are less hazardous to health than saturated fatty acids of animal fats (Oei, 1991).

2.6.3 Carbohydrate Content

Mushrooms have little sugar and no starch at all. It is therefore, an ideal food for diabetics and weight-watchers (Oei, 1991).

2.6.4 Mineral Salt

Mushrooms have a richer supply of minerals than many meats and double the amount found in most vegetables. They probably contain every mineral present in the material on which they grow including substantial quantities of phosphorus, potassium and lesser amount of calcium. Other mineral salts present in mushrooms include sodium, magnesium, manganese, aluminium, zinc, iron and copper (Sawyerr, 1991).

2.6.5 Vitamins

Mushrooms are good source of vitamins such as thiamine (vitamin B1), riboflavin (vitamin B2) niacin (vitamin B12), biotin and ascorbic acid (vitamin C). Mushrooms also have a rich supply of folic acid on larger amounts than any other vegetable or meat with the exception of liver (Oei, 1991).

2.7 MEDICINAL IMPORTANCE OF MUSHROOMS

Lower fungi have yielded important medicines like antibiotics from penicillium. Most of the medicinal extracts from mushrooms are polysaccharides. These extracts are strengtheners of the immune system, with no or little side effects. Mushrooms stimulate immune response and strengthen patients after operation. An extract from the mycelium decreases the excitement of the nervous system, increases the ability of mice to withstand lack of oxygen. Mushroom extracts also provide resistance against fever (Oei, 1991). According to (Oei, 1991), an injection with the spore powder is effective in curing progressive malnutrition of muscles. The tablet of the pore is effective in preventing and curing the non-adaptability to plateau climate. It also increases the activity of lysozyme in the phlegm of patients suffering from chronic bronchitis.

2.8 LEVEL OF MUSHROOM CONSUMPTION

Consumption of mushrooms has been on the increase in the United States over the past several decades. Per capita consumption of mushroom has quadrupled since 1965. In 2001, United States consumption of all mushrooms totalled 5.13 x 10^8kg. Fresh market mushrooms account for two-thirds of domestic consumption. Per capita mushroom use is highest among men and women aged 20-39 and lowest for children under the age of 12 (Gary *et al*., 2003).

Gary *et al.* (2003) reported that the Continuing Survey of Food Intake by Individuals (CSFII) conducted in 1998, data indicated few major differences between men and women in terms of mushroom consumption. Indeed, for all mushrooms, men and women consume mushrooms in exactly the same proportion as their shares of the population. Men account for 49% of the population and reported consuming 49% of all mushrooms, while women account for 51% of the population and reported consuming 51% of all mushrooms. Thus, total per capita mushroom consumption was similar to the national average for each gender, although differences were noted in both fresh and processed markets. For fresh mushrooms, women consuming about 8% more than men at 1.3kg per capita, compared to 1.14kg for men. For processed mushrooms, the situation was reversed, with men consuming an estimated 0.64kg (fresh-weight basis) per capita and women consuming 0.59kg per person. On any given day, nearly 10% of Americans consume mushrooms in some form (Gary *et al.*, 2003).

In Ghana, a study conducted showed that people who understand the value and like the delicate flavour of oyster mushrooms consumed about 1kg a week for those who purchased them at a price of GH¢4-GH¢6 per kg. It is estimated that farmers are currently meeting less than 10% of consumers demand (Bempah, 2011).

2.9 GENERAL LIFE CYCLE OF MUSHROOM

The life cycle of mushroom (Figure 2.1) starts with the microscopic spore produced from the underside or gills of the fully opened mushroom. The spores are carried on air current to considerable heights and for many hours. The spores of some species are also taken away on visiting insects or animals which feed on them. When the spores are deposited on a favourable substrate that has enough nutritious food, sufficient moisture and favourable temperature, they germinate. After germination, they send out small delicate, white filament called hyphae which grows horizontally and intertwine with the hyphae of surrounding spores to form mycelium. During their development, the hyphae produce chemical which digests the food around them and the strands thus grows very quickly through the substrate and for a thick living mass known as the spawn. The first tiny mushroom appears in the form of tiny white pinheads to the surface. These soon form the spherical shapes of the tiny immature mushrooms which develop into fruit bodies (Sawyerr, 1991).

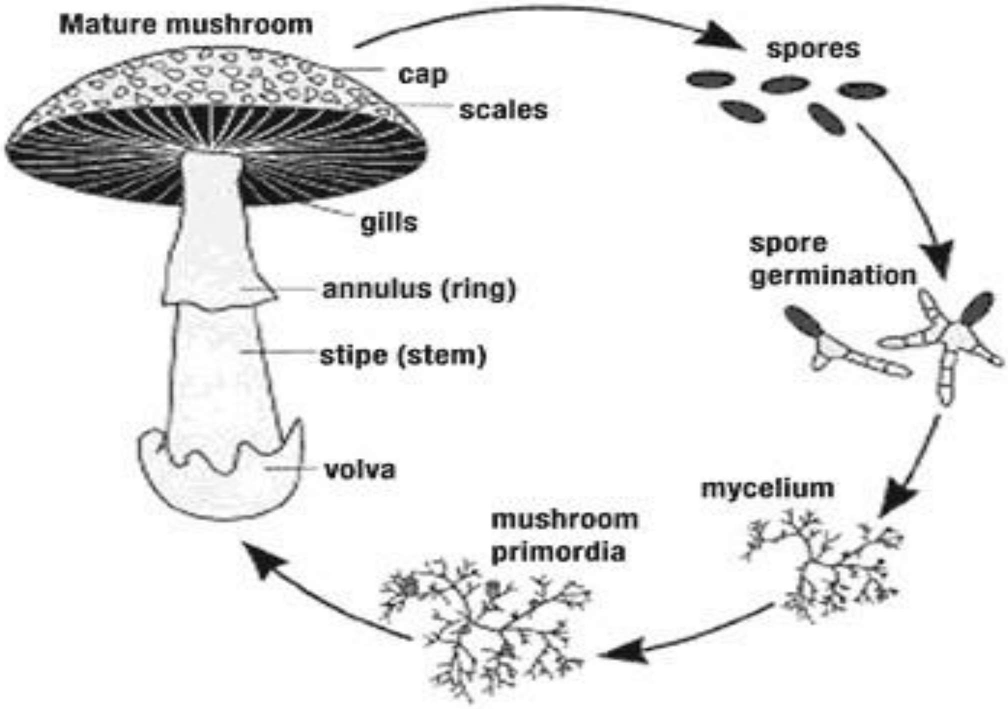


Figure 2.1: Life cycle of mushroom

2.10 MUSHROOM PRODUCTION SYSTEM

The cultivation system adopted in Ghana is a standard method used in many parts of the world. The procedure begins with the preparation of the compost. The most popular material is sawdust, which ideally should first be decomposed. The compost is then put into heat-resistant plastic bags about 33cm long and is heated to kill microorganisms that might compete with the mushrooms for nutrition. When the compost is fully sterilized, the mushroom spawn is inserted. The bags are then kept in a darkened room for several weeks. When the mycelium has spread over the compost, the room is ventilated and a small amount of light is let in, causing the mycelium to develop into mushrooms. Finally the bags are opened and the mushrooms cropped (Sawyerr, 1991).

According to Maher *et al.* (2000), mushroom compost can be manufactured from wheat straw and poultry manure with the addition of water and gypsum (calcium sulphate). These undergo composting and pasteurisation processes after which the compost is selected for the mushroom fungus. The compost is then spawned with mushroom mycelium filled into polyethylene bags, each containing 20kg of compost, and delivered to the mushroom farms. The bags are laid out on a concrete floor in an insulated polyethylene-clad tunnel. When the mushroom mycelium has colonised the compost, a 5cm layer of peat mixed with ground limestone is placed on top. This casing layer induces formation of the sporophore or mushrooms. About a week later, harvesting the mushrooms commences and this continues for about 4 - 6 weeks. The whole process takes 10-12 weeks allowing about five crops per year.

2.11 SPAWN

Oyster mushrooms are grown from mycelium propagated on a base of steamsterilized cereal grain usually millet. This cereal grain-mycelium mixture is called spawn and is used to seed mushroom substrate. Most spawn is made with mycelium from a stored culture, rather than mycelium whose parent was a spore. This is because spores are likely to yield a new strain and performance would be unpredictable and would take time to germinate as well and competitor fungi might germinate and grow faster during that time. Therefore, a pure culture of desired culture of the desired mycelium is added to the substrate to give it an advantage. Inoculum for spawn production is produced in polyethylene bags containing a micro porous breather strip for gas exchange. Most commercial spawn production companies produce spawn only from inoculum that meets strict quality control standards. These standards include verification of inoculum production performance before it is used to produce spawn and insurance of the spawn‟s biological purity and vigour (Royse, 2003).

According to Oei (1991), if old mycelium that yielded mushroom is used to inoculate a new crop, then all the contaminants that have gathered would be inoculated together with the mycelium of the desired mushroom and would eventually spoil the crop.

2.11.1 Spawn Quality

Quality control in spawn manufacturing means constant inspection of the inoculated containers and keeping strict hygienic measures. Infected containers are not used in the incubation room. Good spawn has vigorous mycelial growth and is free from other organisms. If the spawn is stored for too long, the vigour would become less. Spawn from oyster mushroom would become very compact after prolonged storage and is therefore more difficult to apply evenly during spawning. It is advisable to give the mycelium a resting period in between transfers. Keeping it in a refrigerator for some months is better than fast vegetative multiplication all the time. The best way, however, is to start from a fresh mother culture every three months. The fresh mother culture can be obtained from a tissue culture or from culture collections and research stations. Spawns of most cultivated mushroom can be kept for up to six months at 4-6^{o}C after complete colonization of spawn substrate. Always use the complete container of spawn otherwise contaminants would spoil the rest of the spawn (Oei, 1991).

2.11.2 Spawning

Spawning is a process of introducing mushroom spawn (planting material) into compost bags. During spawning, the room is cleaned thoroughly with alcohol or dettol and the cooled compost bags are arranged on a table. The spawn are dislodged into the compost bag by shaking the bottle to loosen the grains. The inoculated compost bags

are arranged on shelves leaving spaces between them to allow for good aeration. Oyster mushroom spawn grows completely through the sawdust compost within 28-41 days. After this period, the mycelium begins to thicken with the bags and starts forming fruiting bodies. The bags are then opened for the fruiting
(Sawyerr, 1991).

2.11.3 Flushing

With constant watering, oyster mushrooms pinheads start to appear in 3-5 days after the bags are opened. When the pinheads appear, they take 3-6 days to develop into buttons. The first crop of mature oyster mushrooms can be obtained 14-21days after spawning and may last 3-5 consecutive days. This is called the first flush. A second flush may appear 5-7 days later and again another can be harvested 2-3 days. Products of mushrooms may continue for two or more months on the rice straws beds and one month on the other bedding material (Oei, 1991).

Sawyerr (1991) observed that within every 7-10 days, another flush can appear and would continue for 2-3 months. A total of 200-250g (0.2-0.25kg) can be harvested within this period. The number of flushes obtained depends on the weather and nutritive content of the substrate. For example, five flushes of rice straw and two flushes for banana leaves.

2.12 MANAGEMENT PRACTICES DURING MUSHROOM PRODUCTION

According to Sawyerr (1991), the greatest attention in mushroom production should be paid to cleanliness as diseases thrive in an unclean house. After two months of flushing, all the compost bags are removed and sprayed with 2.5kg of fresh neem seeds or leaves and mixed with 15 litres of water. The neem seeds or leaves are pounded, mixed with water and strained. The mixture is left to stand overnight and it is used to spray the cropping house.

Ventilation is necessary in the cropping house so that the oyster mushrooms would not develop an abnormally big stalk with a small funnel shaped cap resembling the mouth of a trumpet. The door of the cropping house is opened at night for aeration. Also, sufficient light is provided in the cropping room to prevent the stalk of the mushroom being long and the cap being small (Sawyerr, 1991).

2.12.1 Watering

The floor of the cropping house, the mats and the top of the bags should be moist by watering their surfaces. The watering frequently depends on the surrounding atmospheric humidity. If the humidity is low, watering is done more often and viceversa. Watering is done at least twice a day depending upon the atmospheric humidity (Sawyerr, 1991).

2.12.2 Time of Harvest

The best time to harvest is when the cap begins to emerge from the veil. The harvesting is done in the morning. The mushrooms retain their freshness for at most two days while the open ones will deteriorate after 24 hours (Oei, 1991). During harvesting, a pair of scissors or knife is not used to cut the stalk. Twist off the buttons carefully with the hand without disturbing the attached pinheads which occurs together with them in clusters (Sawyerr, 1991). According to Oei (1991), stumps are not left for soft rot bacteria and green mould to grow on, as the left over portion would decay and spread to succeeding crop causing a drastic reduction in yield due to disease infections.

2.13 CONSERVATION OF MUSHROOM

The aim of conservation is to keep the nutritional value of the crop for a longer period. The nutritional value of fresh mushroom is usually better and the taste may become stronger because of the conservation treatment. The principle behind the different conservation technique differs. In canning, the mushrooms are sterilized and sealed from contaminants, whereas, in drying and salting both result in limited availability of water to micro-organisms and freezing reduces the growth rate of micro-organisms (Oei,1991).

2.13.1 Drying

The age old method of drying mushrooms is still one of the best methods at present practiced all over Italy and many other places in the world. The mushrooms are dried and wrapped in elaborate and expensive displays. The methods vary from sun or air drying to machine and oven drying (Rahart, 2000). According to Oei (1991), drying is based on the principle of limited water availability.

Mushrooms could be set on drying trays or racks and placed under the sun or in dehydrator or oven at a range of temperature between 38-66^{o}C to protect the mushrooms from insects and flies attack. The mushrooms are dried to low moisture level and then placed in air tight bags or jars for storage. The drying method preserves mushrooms for very long periods of time with little or no deterioration in flavour but changes the mushrooms‟ texture. Drying even intensifies the mushroom flavour of many species (Rahart, 2000)

2.13.2 Canning

Since mushrooms have insufficient acid, they are susceptible to *Clostridium botulinum* contamination and require pressure canning to be safely canned. In canning, the mushrooms are sterilized and sealed from contaminants (Rahart, 2000).

However, there is a change in taste with canning, but the products last very long. During canning, the mushrooms are graded and sorted. Spots and blemishes are removed. The adherence of black peat of the casing soil during cultivation is completely washed away. The water for washing the mushrooms sometimes contains 0.1% citric acid or 0.3% sodium metabisulphite to prevent the mushrooms from turning brown (Oei, 1991).

2.13.3 Brining

Brining is a conservation method based on the principle of limiting free water. The high concentration of salt in the solution prevents the growth of micro-organisms. The high number of molecules in the solution increases osmotic tension. Spores cannot germinate because no water is available to them, although there is water all around them. The salt concentration of the solution is about 18%. Per litre of water, 180g to 250g salt must be added to make the solution. The water is boiled and stirred until the salt is dissolved. The brine has to cool before use (Oei, 1991).

The mushrooms should be blanched in a 5% salt solution for five minutes after the water has come to a boil. The mushrooms are drained and cooled. They are then arranged layer by layer and each layer covered with the cooled brine and the container is closed. All the mushrooms are covered with brine all the time. Before use, the mushrooms need to be desalted (Oei, 1991).

2.13.4 Freezing

Freezing preserves taste, flavour and consistency. It requires, however, good transport lines with cooled containers. With freezing, the mushrooms can be kept for at least three months. Freezing as conservation method preserves mushrooms for many consumers. The quick freezing method gives a whiter product, thus improving the appearance of the mushrooms. The mushrooms are transported through a tunnel where they are cooled with nitrogen vapour to -25^{o}C. However, transportation from farm to market requires special equipment (Oei, 1991).

2.13.5 Modified Atmosphere Packaging of Oyster Mushroom

Mushrooms being products with high respiration rate require packaging films with high oxygen and carbon dioxide permeability. Micro perforated and macro perforated films are suitable for use as packaging materials as they are extremely chemical resistant. These are required due to occurrence of anaerobic conditions and physiological damages as a result of high carbon dioxide concentrations. Because of their high oxygen, carbon dioxide and water vapour permeability, these films precludes the possibility of developing an adequate modified atmosphere for packaging high respiring products. The permeability of these films depends on the type of film, its thickness and the number, size and shape of the perforations. During storage, film packaging retarded the deterioration of mushroom appearance, texture and discolouration (Zanderighi, 2001).

According to Villaescusa and Gil (2003), the main changes associated with oyster mushrooms deterioration during postharvest storage are change in colour, caused by enzymatic browning, and the occurrence of soft and spongy texture, due to cell growth and water migration. High texture losses and discolouration to yellow colour can occur after 7 days of storage at 4°C and 7°C.

Ares *et al*. (2007) reported that the most efficient modified atmosphere packaging composition for storage is 1kPa O_2/5-KPa CO_2 in combination with 1% oxygen concentration and can provide quality oyster mushroom acceptable for 10 days of storage. Passive modified atmosphere Packaging of oyster mushroom stored at 4°C in bags of polyvinylchloride (PVC) coated packages can give better visual quality after 7 days of storage (Villaescusa and Gil, 2003). Jayathunge and Illeperuma (2005) observed that Packaging oyster mushrooms in 0.015mm linear low-density polyethylene packages with 3g of magnesium oxide after washing with 0.5% calcium chloride and 0.5% citric acid can extend the postharvest life of oyster mushrooms at 8^oC and 70% relative humidity from 6 days in commercial samples to 12 days.

2.13.6 Controlled Atmosphere Packaging

Ramanathan *et al*. (1992) studied the quality of oyster mushrooms stored in different thickness of polyethylene bags under controlled atmosphere storage and found out that 300 gauge and 150 gauge polyethylene bags maintained the keeping quality of mushroom up to 20 days at 15% CO_2 and 1% O_2 gas composition. According to Zheng Yong Hua *et al*. (1994), 8% O_2 + 10% CO_2 is the best atmosphere for maintaining the quality of fresh mushrooms under controlled atmosphere storage.

2.14 PACKAGING MATERIALS FOR MUSHROOM PRODUCTS

Arumuganathan and Rai (2004) conducted studies to identify the suitable packaging materials for the mushroom products. The different packaging materials used were polythene, polypropylene, lug bottles, laminated pouches, PVC wrapped trays, plastic jars and tin cans. The suitability and adaptability of these packaging materials were studied in terms of keeping quality during the storage period and given in the Table 2.1 below. It is inferred that different products required different type of packaging materials.

Table 2.1: Suitability of packaging materials for mushroom products

Name of the packaging material	Mushroom product	Storage period
Polythene bag	Dried mushroom	2 months
	Mushroom powder	2 Months
Polypropylene	Mushroom candy	6 Months
	Mushroom soup Powder	6 Months
	Mushroom Powder	6 Months
	Dried Mushroom	3 Months
	Mushroom Chips	3 Months
Lug bottles	Mushroom Pickles	1 Year
PET jar	Mushroom Biscuits	3 Months
	Mushroom Candy	6 Months
Butter Paper	Mushroom Candy	3 Months
	Mushroom Biscuits	2 Months
PVC wrapped trays	Mushroom Nuggets	1 Months
Laminated pouches	Mushroom curry	1 Year
Tin Cans	Canned Mushroom	1 Year

2.15 PESTS AND DISEASES OF MUSHROOM

Pests and diseases can harm mushrooms severely. They can affect the crop in several ways. Diseases and pests prevent spawn from growing into the substrate by eating grain spawn and damaging the mycelium. Pests and diseases damage the mushroom itself by causing brown spots on the cap. The most frequent biotic causes for a reduced yield are parasitic fungi, insects, mites, larger animals such as snails or rodents, nematodes pathogenic viruses and pathogenic bacteria (Oei, 1991).

Bacteria are difficult to detect. Some give the grain spawn a greasy appearance and emit a sour smell. Bacteria develop easily in grain spawn. The most common bacterial problem encountered by growers is *Pseudomonas tolaasii*. This is the same bacterium that causes bacteria blotch of *Agaricus bisporus*. Symptoms of the disease include reduced yield and orange discoloration and brittleness of the basidiocarps. Infected mushrooms have a reduced shelf life. Constant and high relative humidity, insufficient air movement, overheating of the substrate (above 35^{o}C), excessive moisture content, and especially a wet mushroom surface may worsen *Pseudomonas tolaasii* infection (Royse, 2003).

A common fungal contaminant is coprinus. It prefers higher temperatures above 38^{o}C and grows faster. The spores of coprinus are abundant in the air. Fungi of the genera *Cladobotryum* and *Verticillium* known to cause disease of *Agaricus bisporus*, are rarely encountered in *Pleurotus* spp. cultivation. These fungi, when they are encountered in oyster mushroom production, may be found mainly on aged basidiocarp and stipe residues (Royse, 2003).

Insects may feed on the substrates, especially at the end of the crop. Termites are a nuisance in mushroom cultivation because they usually appear when the primordial are just formed (Oei, 1991). Insects infesting mushroom tissues cause the greatest losses to growers, particularly during warmest season of the year. The most important insect pests associated with oyster mushroom tissue include Cecidomyiidae *(Mycophila speyeri),* Scatopsidae, Sciaridae *(Lycoriella solani),* and Phoridae *(Megaselia halterata, Mycophila nigra)*. Oyster mushroom primordia are very sensitive to chemical vapors, so using pesticide to control insects is difficult.

Large clusters of deformed oyster mushroom tissue resembling "cauliflower" have been observed after insecticides were applied during primordial formation. Use of various flytraps and adherence to strict hygiene practices, particularly during spawning and spawn run, help keep fly populations below economic threshold levels. In the United States, *Bacillus thuringiensis* var. *israeliensis*, when incorporated into the substrate at spawning, has shown excellent effectiveness against sciarid flies (Royse, 2003).

2.16 MUSHROOM DETERIORATION

Mushrooms are composed of densely packed fine threads known as hyphae which together form a mycelium (Ares *et al.,* 2007). According to Brennan and Gormley (1998), all fresh mushrooms are prone to spoilage but more especially sliced or diced mushrooms. Slicing creates a larger surface area which amplifies the spoilage problems. The main processes or mechanisms responsible for mushrooms‟ sensory quality loss are enzymatic browning, bacterial growth and texture changes. Mushrooms‟ quick deterioration is mainly caused by their high metabolic activity, respiration rate and dehydration (Ares *et al.,* 2007).

Royse (2003) reported that most deformed mushroom may be traced to insufficient ventilation, smoke, chemical vapours, over heated substrate during spawn run, extreme low fruiting temperature below 10^{o}C and insufficient light. Fresh mushroom shelf life is limited to 1-3 days at ambient temperature and 4-7 days at 4^{o}C (Ares *et al*., 2007).

The main changes associated with oyster mushroom deterioration during postharvest storage are change in colour, caused by enzymatic browning and the occurrence of soft and spongy texture, due to cell growth and water migration. High texture losses and discolouration to yellow colour can occur after 7 days of storage at 4°C and 7°C (Villaescusa and Gil, 2003).

According to Brennan and Gormley (1998), mushrooms have a shorter shelf life than most vegetable because their respiration rate is rapid and they have no barrier to protect them from water loss or microbial attack. Enzymatic browning occurs when the enzyme tyrosinase makes contact with its substrate and initiates a series of reactions which produces brown melanin pigments. Contact between the enzyme and its substrate can occur when mushrooms are bruised, cut or damaged by microbial growth. Microbial spoilage of mushrooms is usually due to the growth of pseudomonad bacteria. As these bacteria grow, they break down the mushroom fibres which soften the mushroom and lead to enzymatic browning. The major species responsible for this is *pseudomonas tolaasii* which produces a toxin that lysis mushroom cell. The resulting brown pigments and surface lesions are symptoms of the disease, „bacteria blotch‟. Growth of pseudomonad bacteria also causes slime form on the mushroom surface. A mushroom that is spoiled is slimy and smells rancid.

2.16.1 Respiration Rate

Fresh mushrooms are metabolically active for long periods after harvesting. Respiration is a metabolic process that provides the energy for biochemical process. Aerobic respiration consists of oxidative breakdown of organic reserves (mainly carbohydrate, lipids and organic acids) to simpler molecules including carbon dioxide and water with the release of energy; consuming oxygen in a series of enzymatic reaction (Fonseca *et al.*,2002). When temperature increases around a produce or storage environment gets warmer, all physiological and biochemical reactions within the produce also increase. This leads to increase respiration and early spoilage of the produce (Kumah and Olympio, 2009).

Taking into account that respiration determines the demand of organic resources, respiration rate can be regarded as a measure of the metabolic activity of perishable produce including mushrooms (Fonseca *et al*., 2002). In the case of mushrooms, the harvested sporophore of the cultivated mushroom undergoes a course of development and senescence very similar to that of the growing fruit body. However, substrates of mycelial origin are no longer available for cut sporophore which is therefore supported only by organic reserves. Hence, respiration rate is important in determining deterioration rate and onset of senescence in cultivated mushrooms. Therefore, respiration rate is proportional to product deterioration rate and inversely proportional to its shelf life (Ares *et al.,* 2007). According to Fonseca *et al.* (2002), mushrooms have a high respiration rate compared to other fruits and vegetables making them particularly perishables. A study on the effect of time, temperature and slicing on respiration rate of mushrooms revealed that respiration rates increased initially for some time then, decreased and reached steady state 12, 16 and 20^0C.

2.16.2 Dehydration

Mushrooms are only protected by a thin and porous epidermal structure, lacking the specialized epidermal structure of higher plant tissues. This epidermal layer does not prevent a quick superficial dehydration that causes important quality loss. Water loss from growing mushrooms is comparable to that from a free water surface since 90% of mushrooms weight at harvest, is water. Freshly harvested mushrooms transpire at the same rate as the fruiting sporophore. Dehydration causes economic losses to mushrooms‟ producers and also influences their deterioration rate (Ares *et al*., 2007).

Kumah and Olympio (2009) reported that once produce are harvested, any water from the commodity cannot be replaced by absorption by the roots in the soil. Water loss will lead to wilting, loss of appearance, texture and this represents a loss in quality and weight. If produce are sold on weight basis, water loss may represent considerable decrease in value to the vender. It may also lead to rejection of standard weight packages of produce. It can result in rapid loss of quality. Severe wilting can be induced by storage for even less than 24 hours under hot dry conditions.

2.16.3 Produce Water Loss and Relative Humidity

Fresh fruits, vegetables and ornamentals are mostly composed of water, the unique „universal solvent‟ that is fundamentally important in all life processes. Accordingly, horticultural commodities including mushrooms might be regarded as water in aesthetically pleasing packages. As water is rather costly to put into these attractive packages, it is not surprising that the final product is relatively expensive. It follows that water loss equates to loss of saleable weight, and thus constitutes a direct loss in marketing. Accordingly, measures that minimize water loss after harvest will usually enhance profitability. However, high relative humidity is essential to prevent desiccation and loss of glossiness of perishables (Maalekuu, 2008).

Loss in weight of only 5% will cause many perishable commodities, even bulky fruit which has low surface area to volume ratio, to appear wilted or shriveled. Under warm dry conditions, this level of water loss can occur for some produce like mushrooms in just a few hours. Wilted perishable produce have little or no consumer appeal. Even in the absence of visible wilting, water loss can result in reduced crispness and undesirable changes in colour, palatability and nutritional quality. However, conditions that result in wetting of produce can also result in disastrous losses with some perishable commodities. Free water encourages microbial decay (Maalekuu, 2008). Water loss in mushrooms after harvest is influenced by the status of the mushroom, humidity, exposure to fresh air and atmospheric pressure. When mushroom is wilted or shriveled, the quality of fresh mushroom is lowered (Ares *et al.*, 2007)

2.16.4 Browning

Mushroom browning is an important cause of loss of quality during postharvest storage (Ares *et al*., 2006). Browning occurs as a result of two distinct mechanisms of phenol oxidation and spontaneous oxidation. Tyrosinase oxidizes some monophenols to o-diphenols and spontaneous oxidation is oxidized to quinines which spontaneously polymerize to form brown, black or red pigments. As a result of senescence, cell membranes are disrupted and compartmentalization is lost allowing enzymes and substrates to mix thereby, accelerating browning (Nerya *et al.*, 2006).

2.16.5 Texture Changes

Texture is an important quality parameter for fresh mushrooms. One of the main changes associated with oyster mushrooms deterioration is changes in their texture. Postharvest senescence in a variety of horticultural commodities is accompanied by changes in cell membrane characteristics, which leads to loss of barrier function and loss of turgor. Mushrooms softening or loss of firmness during postharvest storage has been ascribed to changes in membrane. These texture changes are also related to protein and polysaccharide degradation, hyphae shrinkage, central vacuole disruption and expansion of intercellular space at the pilei surface (Ares *et al.*, 2007). These changes lead to mushroom deterioration and can contribute to a massive postharvest loss.

2.17 POSTHARVEST LOSSES OF PERISHABLE PRODUCE

According to the Ghana Science Association (GSA, 2010), postharvest sector includes all points in the value chain from production in the field to the food being placed on a plate for consumption. Postharvest activities include harvesting, handling, storage, processing, packaging, transportation and marketing.

According to the Food and Fertilizer Technology Centre (FFTC, 2007), fresh produce including mushrooms are inherently perishable. During the process of distribution and marketing, substantial losses are incurred which range from a slight loss of quality to total spoilage. Postharvest losses may occur at any point in the marketing process, from the initial harvest through assembly and distribution to the final consumer. The causes of losses can be due to physical damage during handling and transport, physiological decay, water loss or sometimes simply because there is a surplus in the market place and no buyer can be found.

Occasionally, losses may be 100% when there is a price collapse and it would cost the farmer more to harvest and market the produce than to plough it back into the ground. There can be losses in quality, as measured both by the price obtained and the nutritional value, as well as in quantity (Wikipedia, 2011). It has been estimated by various authorities that 20-80% of fresh produce are lost after harvest. In the tropics and subtropics, estimate of losses are put at between 40-50% and sometimes as high as 100% for certain crops (Kumah and Olympio, 2009). This might be due to high temperatures.

In Ghana, postharvest losses account for more than half of the losses in agricultural sector. These losses may occur during processes such as harvesting, threshing, shelling, drying, storage, processing, transportation and marketing (GSA, 2010). According to the Ghana Science Association (2010), perishable produce contain about 75% of water and a reduction in moisture content would result in wilting due to dehydration and subsequent deterioration. The amount of resources used and the efficiency of production are contingent upon use of appropriate technologies, infrastructure, storage, processing, transportation and marketing.

Insufficiencies in one of these areas result in significant amount of crop loss. This may be due to wrong harvesting time, inappropriate harvesting technique, incorrect stage of produce, extreme temperatures, physical damage, contamination by pests and market conditions. In developing countries, losses of between 40 to 75% have been reported (GSA, 2010).

Postharvest losses result not only in loss of the actual crop, but also losses in resources, labour needed to produce the produce and livelihood of individuals involved in the production process. For instance, when 30% of a harvest is lost, it means that 30% of all the factors that contributed to producing the crop are also wasted (GSA, 2010).

In tropical and subtropical countries, the warm, humid climate adds more stress and accelerates the decay of tropical produce. Postharvest losses of fresh produce in most

Asian countries range from 20-50%. The rate of postharvest losses of horticulture produce in Korea are put between 10- 36%. Specifically, the loss rate for Chinese cabbage is estimated to be around 30% in all countries in Asia, but the loss factors differ from country to country. Over production and market failure could contribute greatly to these postharvest losses (FFTC, 2007).

2.17.1 Postharvest Handling Losses

According to Food and Fertilizer Technology Center (2007), out of the 17 million metric tonnes of vegetable produced in Japan in 1991, there was a 10% loss during handling and distribution. Most of these losses occurred at the retail and home consumption level. In Chinese cabbage for example, there was only 2% loss at a retail level while the remaining 17% occurred in the consumers‟ home. Losses of perishable produce in Korea estimated as 32% in 1980 and as 27% in 1993. Levels of home losses in Korea for fruits estimated as 42% for water melon, 29% for grape and

25% for mandarin orange.

2.17.2 Post Harvest Losses in the Ho Municipality

Postharvest losses are common phenomena and represent a major challenge to farmers in the Ho municipality. The incidence of postharvest losses is particularly very high for perishable crops like tomatoes (60%), mango (53%), cassava (45%), garden eggs (45%) and pepper (40%). These losses have come about because of the general lack of knowledge about preservation techniques and the inadequacy of appropriate processing and storage facilities. The high incidence of postharvest losses affects the incomes of farmers and has been a disincentive to farmers who want to embark on large scale production (Ho Municipal Planning Committee Unit, 2011).

According to Agyei *et al*. (1993), inadequate storage facilities do not allow the farmers to maintain some kind of food security. Adequate storage and suitable facilities are required to make it possible to store produce including mushrooms under appropriate conditions for long periods of time. The immediate effect of inadequate storage facilities for mushrooms is that producers are very anxious to dispose of their produce soon after harvest to minimize postharvest losses. This results in price fluctuations and instability in the marketing of the produce.

2.18 POSTHARVEST TREATMENT

Mushrooms are a highly perishable crop. Wilting, ripening, liquefaction and change of flavour, texture and constitution decrease the value significantly. The shelf life can be increased by storage at very cold temperatures and wrapping in plastic. A number of conservation methods have been developed, differing according to the aimed market and available resources and infrastructure. Canning, air drying, brining, freeze-drying and freezing are methods employed in mushroom conservation (Oei, 1991).

Fresh mushrooms for the fresh market are packed with a plastic film and cooled after harvest for sale under ideal conditions. The plastic film gives good protection from water loss as long as the temperature is more or less constant. A repeated exposure to fluctuating temperatures would result in wilted mushrooms. Mushrooms (*Agaricus sp)* kept at 4^{o}C can stay fresh for about one week. Carbon dioxide (3-6%) can be achieved by a plastic film around the packaging. Quick cooling with moistened circulating air directly after picking is best (Oei, 1991).

According to Rai and Arumuganathan (2008), experiments showed that keeping oyster mushroom at 8 to 10^{o}C in pre-packs wrapped in perforated polyethylene films is a good treatment for keeping the mushrooms fresh for 4 days. The ideal storage temperature for *Volvariella volvacaea* is 15^{o}C. At low temperatures (4 - 6^{o}C), the mushrooms liquefy rapidly. Mushrooms packed on completely closed bags can be kept for less than 3 days. In perforated bags at 10^{o}C, the mushrooms can be kept for 4 days. Storing at 15^{o}C gives a better quality.

2.19 VALUE ADDITION OF MUSHROOMS

The term value added refers to the value created in a product in the course of manufacturing or processing exclusive of such costs as those of raw materials, packaging or overhead (Stevenson and Lentz, 2009). In other words, it is the additional value of a commodity over the cost of commodities used to produce it gfrom the previous stage of production (Rai and Arumuganathan, 2008).

In India, almost the entire domestic trade of mushroom is in the fresh form while all the exports is in the preserved formed (canned or steeped). The current era is characterized by greater awareness about quality and the demand for the „„„readymade"" food products (Rai and Arumuganathan, 2008). As mushrooms contain high moisture and are delicate in texture, they cannot be stored for more than 24 hours at the ambient conditions of the tropics. Weight loss, veil opening, browning, liquefaction and microbial spoilage often make the products totally unsaleable.

Effective processing techniques reduce the postharvest losses and result in greater remuneration to the growers and processors (Rai and Arumuganathan, 2008).

Value can be added to the mushrooms at the various levels and to varied extent, right from grading to the „‟readymade‟‟‟ snacks or the main-course items. A real valueadded product in the Indian market is mushroom soup powder. Technologies for production of some other products like mushroom based biscuit, nuggets, preserve, noodles, papad, candies and „‟readymade‟‟‟ mushroom curry in retort pouches have been developed. Improve and attractive packaging known as secondary value addition adds value to mushroom products. Small growers add value to mushroom by grading (Rai and Arumuganathan, 2008).

3.0 MATERIALS AND METHODS

3.1 INTRODUCTION

First of all, with regards to field survey, a preliminary survey was conducted with mushroom marketers to identify oyster mushrooms producers in the Ho Municipality. A visit was made to the oyster mushroom producers to acquaint with production activities of oyster cultivation mushroom in the Municipality and for firsthand information on the nature of oyster mushrooms being cultivated in the area. On the basis of this, the number of producers, marketers and consumers were selected for the study. The survey was conducted from Nov-Dec 2011.

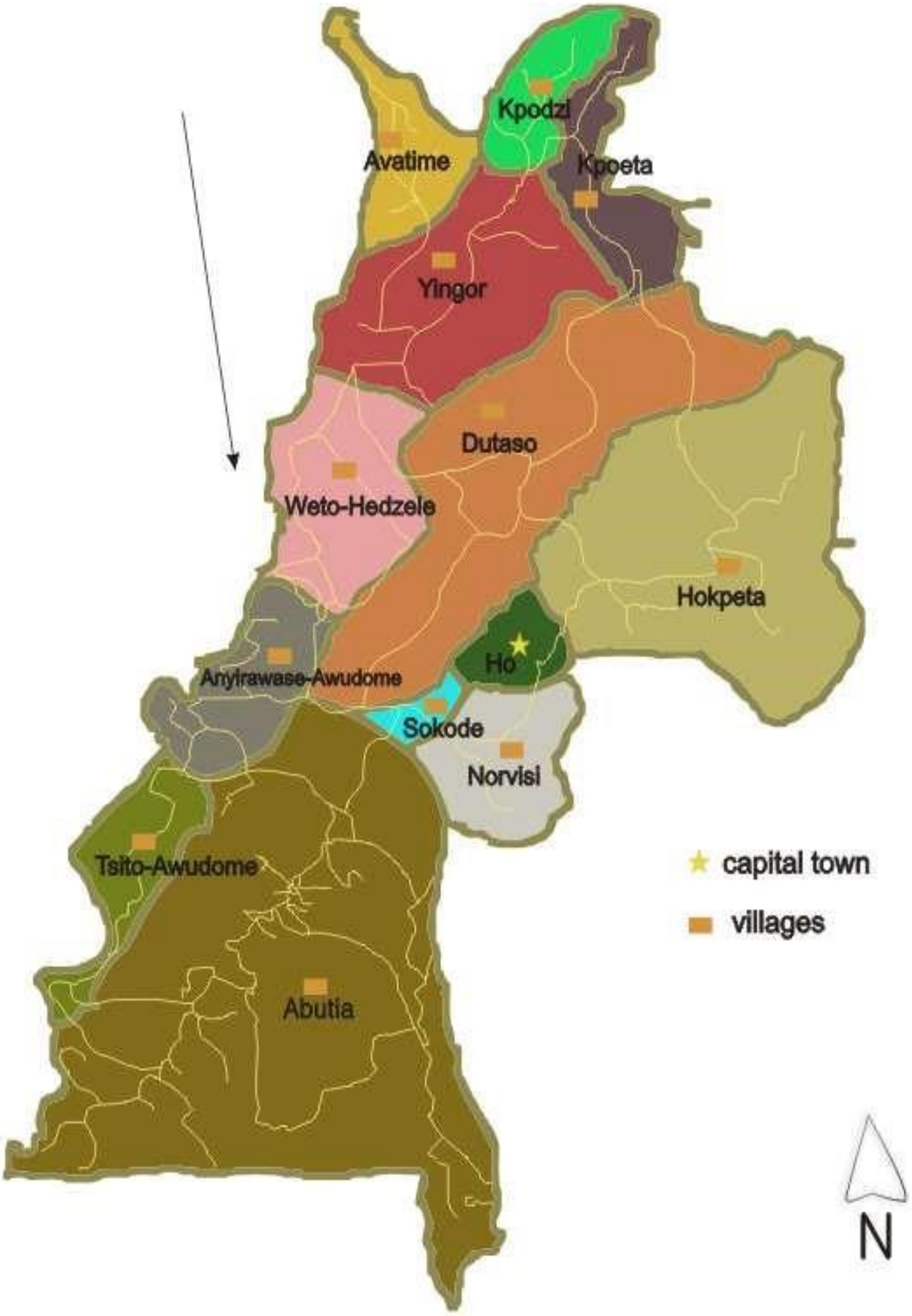
However, laboratory study was conducted as a follow up on the key postharvest loss indices of samples of the oyster mushrooms produced in the Ho Municipality in order to corroborate the results obtained from the survey and to help validate the results obtained. The laboratory study was conducted in March, 2013.

3.2 FIELD SURVEY

3.2.1 The Study Area

The Ho Municipality lies between latitudes 6° 207‟ N and 6° 55‟ N and Longitudes 0° 127‟ E and 0° 53‟ E and covers an area of 2660Km^2. The Municipality shares boundaries with the Adaklu-Anyigbe District to the South, Hohoe Municipal to the North, South-Dayi District to the West and the Republic of Togo to the East. By Location, Ho Municipality has economic co-operation with neighbouring districts.
The rainfall pattern is characterized by two rainy seasons referred to as the major and the minor seasons. The vegetation of Ho municipality is basically savannah woodland, which covers most part of the city. However, there are patches of semideciduous forest which mostly occur on the highlands (Ho Municipal Planning Committee Unit, 2011).

The general relief of the Ho Municipality falls into mountainous part and low land areas. The mountainous areas are mostly of the north and north east which are part of the Akuapim Togo ranges and have heights between 183-853m. The notable areas are Awudome stretch in the south-west to Avatime and Ashanti Kpoeta in the Northeast. The low land areas are to the south of the municipality and have heights between 60-152m. The topography in the Municipality imposes steep slopes and rapid run-offs during the rainy seasons. The general drainage pattern is southwards and dominated by rivers like Tsawe (Alabo) and Kalapa, which eventually flow in to lower Volta lagoon (Ho Municipal Planning Committee Unit, 2011).



Source: Ho Municipal Assembly, 2011.

Figure 3.1: Municipal map of Ho

3.2.2 The Target Population

The target population was mushroom producers, marketers and consumers in the Ho Municipality of the Volta Region.

3.2.3 Sources and Data Collection Techniques

The research was carried out in the Ho municipality starting from 10th November to 30th December 2011. Both primary and secondary data were collected from the study area. The primary data was obtained from the producers, marketers and consumers through the administration of both structured and semi-structured questionnaires. The producers, marketers and consumers were identified in the municipality. This was done before questionnaires were administered. In addition, participants‟ observation was carried out to gain in-depth picture of the situation on the ground.

Secondary data were obtained from Ho Municipal Assembly, Ministry of Food and Agriculture, libraries as well as the internet. After the questionnaires had been administered, a follow up visit was made to authenticate the feedback that had been received.

3.2.4 Sampling Procedure and Size

Purposive sampling method was used to obtain primary information from the producers of oyster mushroom due to limited number of oyster mushroom producers that have the expertise in the mushroom industry in the study area. With regards to the marketers and consumers, the study area was divided into four (4) groups and simple random sampling procedure was used to select the respondents. In all, 135 questionnaires were administered to 30 producers, 35 marketers and 70 consumers.

3.2.5 Questionnaires Administration

Both structured and semi-structured questionnaires were used to collect data in the study area to generate primary information. In each area, producers, marketers and consumers were interviewed. Pre testing of questionnaires was done and discussion of certain responses for classification was successfully carried out before the final survey was done.

3.2.6 Data Analysis

The data gathered were analyzed by the use of Statistical Package for Social Science (SPSS) version 16.0. The results were interpreted and presented using descriptive statistics in the form of frequency tables, bar charts and pie charts. Linear regression analysis version 9.0 using stepwise methods was used in estimating the major factors that contributed to losses in oyster mushroom production at the producer, marketer and consumer levels.

3.3 LABORATORY EXPERIMENTS

The laboratory experiments were carried out in the Peki Senior High School Science Laboratory in March, 2013.

3.3.1 Preparation of Oyster Mushroom for the Experiments

The oyster mushrooms were sorted by size and appearance. Damaged, fully veil opened and extremely large or small oyster mushrooms were discarded to minimize biological variability. One hundred and eighty (180) pieces of freshly harvested mushrooms of fully intact veil were used. The mushrooms were divided into three groups. Each group contained sixty (60) pieces of oyster mushrooms.

The first group which contained sixty (60) pieces of oyster mushrooms were packaged into low density perforated polythene bags (four 1cm diameter holes) and opened transparent plastic bowls of equal size and shape and the packaging was done immediately after harvest for storage. The oyster mushrooms in this group were divided again into two sub-groups and each sub-group contained 30 pieces of oyster mushrooms. In the first sub-group, six (6) pieces of the perforated polythene bags (four 1cm diameter holes) were used. Five pieces of oyster mushrooms were packaged into the six perforated polythene bags. Three (3) of the packages were stored in a refrigerator at 2-3^{0}C for 8 days and the remaining three of the packages were stored at an average room temperature of 24^{0}C with 87% relative humidity for 3 days. In the second sub-group which also contained 30 oyster mushrooms, six opened transparent plastic bowls were used. Five pieces of oyster mushrooms were also packaged into the six opened transparent plastic bowls. Three of the packages were stored in a refrigerator at 2-3^{0}C for 9 days and the remaining three packages were stored at room temperature of 24^{0}C with 87% relative humidity for 5 days.

The second group which also contained sixty (60) pieces of oyster mushrooms were packaged into low density perforated polythene bags (four 1cm diameter holes) and opened transparent plastic bowls of equal size and shape and the packaging was done 12 hours after harvest for storage. The oyster mushrooms in this group were divided again into two sub-groups and each sub-group contained 30 pieces of oyster mushrooms. In the first sub-group, six (6) pieces of the perforated polythene bags (four 1cm diameter holes) were used. Five pieces of oyster mushrooms were packaged into the six perforated polythene bags. Three of the packages were stored in a refrigerator at 2-3^{0}C for 8 days and the remaining three of the packages were stored at an average room temperature of 30^{0}C with 61% relative humidity for 3 days. In the second sub-group which also contained 30 oyster mushrooms, six opened transparent plastic bowls were used. Five pieces of oyster mushrooms were also packaged into the six opened transparent plastic bowls. Three of the packages were stored in a refrigerator at 2-3^{0}C for 9 days and the remaining three packages were stored at an average room temperature of 30^{0}C with 61% relative humidity for
5 days.

Furthermore, the third group which also contained sixty (60) pieces of oyster mushrooms were packaged into low density perforated polythene bags (four 1cm diameter holes) and opened transparent plastic bowls of equal size and shape and the packaging was done 24 hours after harvest for storage. The oyster mushrooms in this group were divided again into two sub-groups and each sub-group contained 30 pieces of oyster mushrooms. In the first sub-group, six (6) pieces of the perforated polythene bags (four 1cm diameter holes) were used. Five pieces of the oyster mushrooms were packaged into the six perforated polythene bags. Three of the packages were stored in a refrigerator at 2-3^{0}C for 7 days and the remaining three of the packages were stored at an average room temperature of 25^{0}C with 85% relative humidity for 2 days . In the second sub-group which also contained 30 oyster mushrooms, six opened transparent plastic bowls were used. Five pieces of oyster mushrooms were also packaged into the six opened transparent plastic bowls. Three of the packages were stored in a refrigerator at 2-3^{0}C for 8 days and the remaining three packages were stored at an average room temperature of 25^{0}C with 85% relative humidity for 4 days.

3.4 DESCRIPTION OF THE EQUIPMENT USED FOR THE EXPERIMENTS

3.4.1 Refrigerator

A Samsung refrigerator frost free type with model RT26ADTS1/XTL manufactured in 2010 and made in India was used for the experiments.

3.4.2 Digital Electronic Weighing Scale

A Scout Pro balance with model SPU402 manufactured in 2009 and made in China was used to measure the weight loss of the individual samples during the experimental periods.

3.5 PARAMETERS ASSESSED

3.5.1 Weight Loss of oyster mushroom

The oyster mushrooms in the storage environment were observed and weighed daily with digital electronic weighing scale and the amounts of weight loss each day due to dehydration were recorded and it was observed that the mushroom structure shriveled or withered due to loss in weight of experimental unit. Weight loss was calculated thus:

$$\% \text{ Weight loss} = \left(\frac{\text{Initial weight - final weight}}{\text{Initial weight}}\right) \times 100\%$$

3.5.2 Shelf life of oyster mushrooms

The shelf life was determined by the length of time (number of days) the mushrooms remained usable and fit for consumption or saleable from the day and time of harvesting and packaging into storage where fresh water loss, colour change, texture and aroma and flavor were observed. The mushrooms developed sticky or slimy spot on the structure. The mushrooms loss their firmness and smelled rancid or of ammonia. Discolouration is an indicator of mushrooms deterioration which eventually contributed to quality loss of the mushrooms. Colour wheel and chart were used to determine the colour changes of the mushrooms (Appendix 4).

3.6 EXPERIMENTAL DESIGN

A 3x2x2 factorial experiment established in a Completely Randomized Design (CRD) and treatments were replicated three times. The factors consisted of three different packaging periods (0 hour, 12 hours and 24 hours), two different packaging materials (perforated polythene bags and open transparent plastic bowls) and two storage environments (refrigerator and room temperature).

3.7 STATISTICAL ANALYSIS

Data collected were subjected to statistical analysis using Analysis of Variance (ANOVA). Repeated measures ANOVA (RM ANOVA) and a subsequent post-hoc Tukey test was conducted on all computed weight losses for all time-dependent treatments to identify any true or significant interactions and possible significant differences between treatments. GraphPad Prism (version 4.0) was used for all statistical analyses.

4.0 RESULTS

This chapter presents the findings of the questionnaires elicited from the respondents who comprised of oyster mushroom producers, marketers and consumers selected from the Ho Municipality. It also contained findings from the laboratory experiments conducted on the key postharvest loss indices of samples of oyster mushrooms produced in the Ho Municipality.

4.1 FIELD SURVEY

4.1.1 Demographic Characteristics of Oyster mushroom producers

4.1.1.1 Age distribution of oyster mushroom producers

As indicated in Table 4.1 below, the study showed that mushroom producers within 31-40 years age group constituted the majority representing 36.7% of the respondents. This was followed by the 41-50 years age group 26.7% while the 51-60 and 60 years and above age groups respectively formed 23.3% and 13.3% of the mushroom producers interviewed.

Table 4.1: Age distribution of oyster mushroom producers

Age group	Frequency	Percentage (%)
20 and below	0	0
21-30	0	0
31-40	11	36.7
41-50	8	26.7
51-60	7	23.3
Above 60	4	13.3
Total	**30**	**100**

4.1.1.2 Gender distribution of producers

The study revealed (as indicated in Figure 4.1) that 63% of the oyster mushroom producers were males and 37% were females.

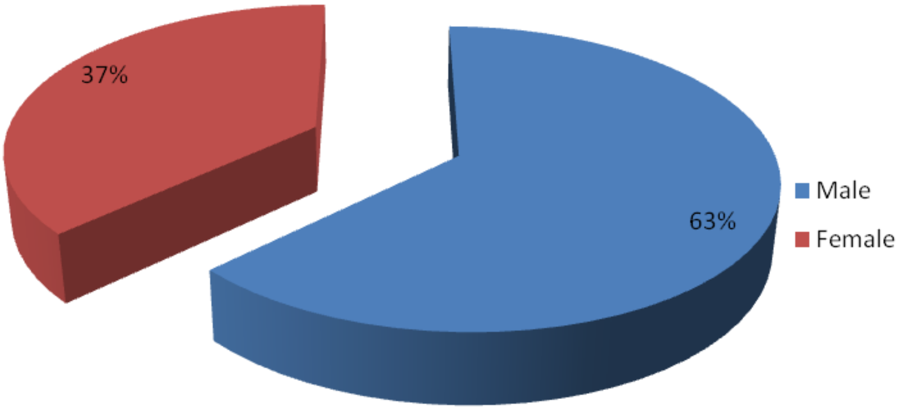


Figure 4.1: Gender distribution of producers

4.1.1.3 Educational background of oyster mushroom producers

The majority of mushroom producers that formed 43.3% had secondary education, 33.3% had basic education and 16.7% attained tertiary education level while only 6.7% of the oyster mushroom producers had no formal education.

Table 4.2: Educational background of producers

Education Level	**Frequency**	**Percentage (%)**
Non-formal	2	6.7
Basic	10	33.3
Secondary	13	43.3
Tertiary	5	16.7
Total	**30**	**100**

4.1.1.4 Religion of producers

From the study, 76% of the producers were Christians, 7% Muslims and 17% were Traditional African worshippers.

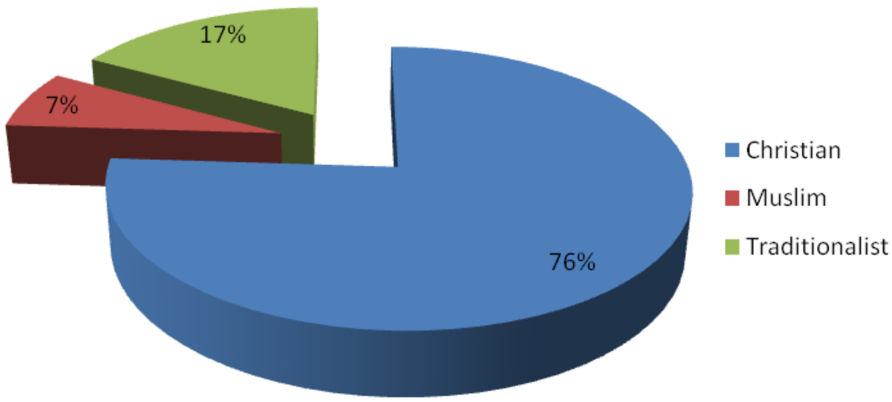


Figure 4.2: Religion of producers

4.1.2 Number of Years Involved in the Production of Oyster Mushroom This information was gathered to determine the impact of the depth of experience on the ability to better produce and handle the mushroom as shown in Table 4.3 below.

Table 4.3: Number of years involved in the production of mushrooms

Number of years	Frequency	Percentages (%)
Less than 1 year	0	0
1-3 years	5	16.7
4-6 years	13	43.3
7-9 years	10	33.3
10-12 years	2	6.7
Above 12 years	0	0
Total	**30**	**100**

Table 4.3 above showed that 43.3% of the producers had 4-6 years‟ experience in the production of oyster mushroom and 33.3% had been producing the mushroom for 7-9 years while 16.7% had 1-3 years‟ experience in the production. Those who had been producing for 10-12 years constituted 6.7%. None of them had more than 12 years‟ experience in oyster mushroom production.

4.1.3 Mushroom Types, Seasons and Production System

4.1.3.1 Mushroom types produce in the Ho Municipality

The research indicated that 93.3% of the producers‟ cultivated only oyster mushroom while 6.7% cultivated oyster mushroom cum oil palm mushroom. None of them cultivated oil palm mushroom only.

Table 4.4: Mushroom type produced in the study area

Types of mushroom	Frequency	Percentage
Oyster mushroom	28	93.3
Oil palm mushroom	0	0
Oyster mushroom and oil palm mushroom	2	6.7
Total	**30**	**100**

4.1.3.2 Seasons of oyster mushroom cultivation

The preferred seasons for mushroom cultivation vary from individual producers as can be seen in Table 4.5 below.

Table 4.5: Seasons of oyster mushroom cultivation in the study area

Seasons of Cultivation	Frequency	Percentage
All year round	22	73.3
Dry season	3	10
Rainy season	5	16.7
Total	**30**	**100**

Table 4.5 above showed that the majority of mushroom producers (73.3%) cultivated oyster mushroom all year round provided mushroom spawns and substrates are available and 10% preferred to cultivate the mushroom in the dry season when the local types such as *Termitomyces species* collected from the wild were out of season such that the price could go higher for the cultivated oyster mushroom while 16.7% specifically preferred to cultivate the mushroom during the rainy season since the temperature during the rainy season favours good harvest.

4.1.3.3 Mushroom production system

In the study area, it was observed that the procedure started with the preparation of the compost. All the producers (100%) used sawdust collected from sawmill to cultivate oyster mushroom while those who also cultivated oil palm mushroom used agriculture wastes such as plantain or banana leaves and cassava peels collected from surrounding farms. The producers practiced indoor method of cultivation and obtained the spawns from Agriculture Extension Agents in the study area.

The plastic bag method was used for cultivation of oyster mushroom. The sawdust compost was packed in heat resistant high density plastic bags and steam sterilized for 2-3hours to kill micro-organisms. The cooled substrate was later inoculated with spawn and incubated in semi-dark conditions.

With regards to edible maturity of oyster mushroom, it was revealed that the period of maturity of the mushroom for harvest varied slightly from the producers. With this, 70% of the producers harvested the mushroom within 26-30days after spawning while 30% did their harvest within 21-25days after spawning (Appendix 1.11). The number of harvest per week is between either 2-3days or 3-4days (Appendix 1.12). These were attributed to appropriate management practices carried out and the nature of the substrates.

4.1.4 Quantity of Oyster Mushroom Bags Raised in the Production House Table 4.6 below showed quantity of oyster mushroom bags raised by producers in their respective production houses.

Table 4.6: Quantity of oyster mushroom bags raised in the production house

Quantity of Bags	Frequency	Percentage (%)
Less than 500	0	0
500-1000	4	13.3
1001-1500	12	40
1501-2000	9	30
2001-3000	3	10
Above 3000	2	6.7
Total	**30**	**100**

As indicated in Table 4.6 above, the result of the interview showed that 40% and

30% of the producers of oyster mushroom respectively had 1001-1500 and 15012000 bags of oyster mushroom in their production house while 13.3% had 500-1000 bags of oyster mushrooms. Also, 10% had 2001-3000 bags and 6.7% had more than 3000 bags of oyster mushroom in their production houses.

4.1.5 Level of Production of Oyster Mushroom per Week in the Ho Municipality

As indicated in Table 4.7 below, the data obtained showed that 43.3% of the growers produced about 41-50kg mushroom per week and 16.7% of the growers produced about 51-60kg mushroom per week while 13.3% produced about 21-30kg mushroom per week and 10% each produced 10-20kg mushroom per week and 31-40kg mushroom per week. Also, 6.7% produced more than 60kg mushroom per week in the Municipality. The producers sold the fresh mushrooms at GH¢3.00 per kg to customers and GH¢5.00 per kg dried mushrooms.

Table 4.7: Level of oyster mushroom produced per week in the Ho Municipality

Quantity produced (kg/week)	**Frequency**	**Percentage (%)**
Less than 10	0	0
10-20	3	10
21-30	4	13.3
31-40	3	10
41-50	13	43.3
51-60	5	16.7
Above 60	2	6.7
Total	**30**	**100**

4.1.6 Level of Postharvest Losses of Oyster Mushroom in the Ho Municipality

4.1.6.1 Level of postharvest losses on the farm

Postharvest losses could stem from metabolic factors and environmental conditions etc. The type of loss which occurred on the farm was in the form of quality loss. This involved physiological disorders of the oyster mushroom structure in the form of upward bending of the cap and fully opened veil. Mushrooms of these disorders were rejected by the marketers. The quality loss also involved bruises of the mushroom structure due to rough handling and also development of brown colouration as a result of high temperatures. Food losses also occurred due to pest attacks and disease infections on the field. Table 4.8 below showed the level losses on the farm.

Table 4.8: Level of postharvest losses of oyster mushrooms on the farm

Level of losses	Frequency	Percentage (%)
1-5%	2	6.7
6-10%	15	50
11-15%	3	10
16-20%	2	6.7
21-25%	7	23.3
26-30%	1	3.3
Total	**30**	**100**

As indicated in Table 4.8 above, it came to light that 50% of the producers experienced losses between 6-10% of the mushroom on the farm while 23.3% experienced losses between 21-25%. Also, 10% of the producers experienced losses between 11-15% and 6.7% each had losses between 1-5% and 16-20% while 3.3% had losses between 26-30%. However, the severity of losses encountered by the majority (50%) of the producers on the farm was low; as low as 6-10% while the severity of losses incurred by few producers (3.3%) were very high and fell within 26-30%. Again, the severity of losses encountered by 23.3% producers were high and was put at 21-25%.

4.1.6.2 Level of postharvest losses during postharvest handling operations by producers

Level of postharvest losses with their severity on oyster mushrooms during postharvest handling operations was indicated in Table 4.9 below.

Table 4.9: Level of losses during postharvest handling operations by producers

Level of losses (%)	Frequency	Percentage (%)
1-5	1	3.3
6-10	20	66.6
11-15	2	6.7
16-20	5	16.7
21-25	0	0
26-30	2	6.7
Total	**30**	**100**

Table 4.9 above showed that 66.6% of the producers experienced losses between 610% during postharvest handling operations while 16.7% experienced losses between 16-20% and 6.7% each experienced losses between 11-15% and 26-30% while 3.3% experienced losses between 1-5%. However, the severity of losses encountered by the majority (66.6%) of producers was low and fell within 6-10% and severity of losses encountered by few (3.3%) oyster mushroom producers was very low and was between 1-5%, whereas, the severity of losses experienced by

6.7% of the producers was very high and was between 26-30%.

4.1.7 Factors Contributing to Postharvest Losses of Oyster Mushroom at Farm Level

The various factors that contributed to postharvest losses of oyster mushroom in the study area were identified as shown in Table 4.10 below.

Table 4.10: Factors that contributed to postharvest losses of oyster mushroom at farm level

Factors	Frequency	Percentage (%)
High moisture content	10	33.3
Poor storage technology	5	16.7
Postharvest changes	6	20.0
Pests and diseases infestation	4	13.3
Environmental conditions	2	6.7
Metabolic factors	2	6.7
Limited alternative preservation technology	1	3.3
Total	**30**	**100**

The result revealed as indicated in Table 4.10 above that 33.3% of the producers interviewed attributed postharvest losses of their produce to high moisture content of the mushrooms and 16.7% mentioned poor storage technology while 20% attributed the losses to postharvest changes of the mushroom. Also, 13.3% stated pests and diseases infestation and 6.7% each attributed the losses to environmental conditions and metabolic factors while 3.3% of the respondents mentioned limited alternative preservation technology.

4.1.7.1 Regression analysis of factors contributing to postharvest losses

As indicated in Table 4.11 below, the model summary from the regression analysis at the producer level revealed that time of harvesting of the oyster mushrooms explained about 54.5% (R^2 = 0.545) of the variation in the losses recorded at the producer level.

Other factors or causes include high moisture content, poor storage technology, postharvest changes, pests and diseases infestation, environmental conditions, metabolic factors and limited alternative preservation technology (Table 4.10). The regression model is highly significant ($P<0.05$) therefore can be used for future prediction of losses at producer level (Appendix 1.1). However, the value of beta coefficient B_1 is 0.844. Since $B_1 \neq 0$ there is enough evidence that time of harvesting was a major factor that contributed to postharvest losses of the oyster mushroom at the producer level (Appendix 1.2).

Table 4.11: Model summary

Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
1	.738[a]	.545	.529	1.004

a. Predictors: (Constant), Time of harvesting

4.1.8 Problems Faced in Oyster Mushroom Production

The producers attributed problems to more than one reason as indicated in Table 4.12 below.

Table 4.12: Problems faced in mushroom production

Problems faced by producers	Frequency	Percentage (%)
Lack of financial support	30	100
Climatic problem	22	73.3
High cost of spawn	30	100
Storage problem	18	60.0
High cost of labour	26	86.7
Pests and diseases infestations	8	26.7
Postharvest changes	28	93.3
High cost of mushroom house construction	13	43.3

From Table 4.12 above, producers recounted their problems as lack of financial support (100%), high cost of spawn (100%) and 93.3% mentioned postharvest changes of the harvested mushroom while 86.7% mentioned high cost of labour and 73.3% identified climatic problems. Also, 60% of them mentioned storage problems while 43.3% and 26.7% respectively mentioned cost of mushroom house construction and pests and diseases infestations.

4.1.9 Management Practices Carried Out During the Production of Oyster Mushroom

From the study, came to light that all the oyster mushroom producers interviewed carried out some management practices that enhance the development of the mushrooms. All the producers (100%) carried out each of the management practices included watering at interval, provision of ventilation, and regular inspection of the mushrooms in the mushroom house and in addition, 70% of them disinfected compost bags getting to two months of flushing with neem tree extract.

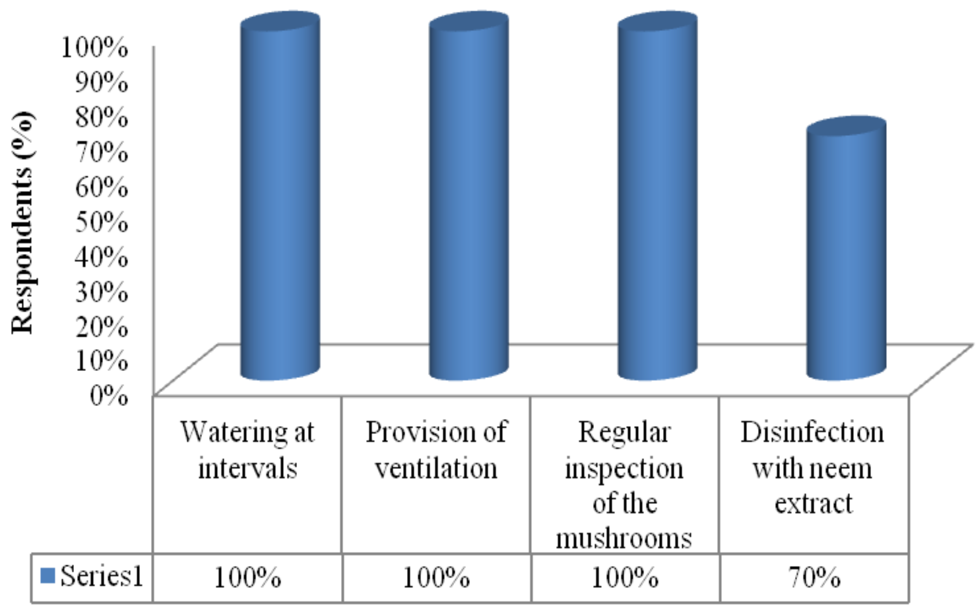


Figure 4.3: Management practices

4.1.10 Time of Harvest of Oyster Mushroom in the Study Area

As indicated in Table 4.13 below, from the study, it was observed that majority of the producers (70%) often harvested the mushroom in the morning which happened to be the time the marketers normally arrived. Although, almost every producer knew that mushrooms are best harvested in the morning due to their high rate of perishability, 23.3% had no specific time of harvesting and 6.7% of the respondents harvested in the afternoon and reported that harvesting in the afternoon resulted to rapid wilting. These groups of producers harvested anytime in the day when the marketers arrived.

Table 4.13: Time of harvest of oyster mushroom in the study area

Time of Harvest	Frequency	Percentage (%)
Morning	21	70
Afternoon	2	6.7
Evening	0	0
No Specific time	7	23.3
Total	**30**	**100**

4.1.11 Postharvest Handling of Oyster Mushroom by Producers

In the study area, harvesting was done by all the producers (100%) by the use of a pair of scissors and the harvested mushrooms were placed directly into plastic bowls. Postharvest handling methods practiced by the producers observed were sorting, packaging and storage. The package material mainly used was low density white perforated polythene bags.

4.2 MARKETERS OF OYSTER MUSHROOM

4.2.1 Demographic Characteristics of Marketers

4.2.1.1 Age and gender distributions of oyster mushroom marketers

The marketers were mushroom retailers who handled the product from the farm gate to the final point of consumption. From Table 4.14 below, it was revealed that 37% of the marketers were found to be within the 41-50 years age group while 20% fell within 21-30 years age group and 17%, 11.4%, 8.6% and 6% fell in the 31-40, 51-60, more than 60 and 20 and below years age group respectively. More so, all the marketers were females.

Table 4.14: Age distribution of oyster mushroom marketers

Age group	Frequency	Percentage (%)
20 and below	2	6
21-30	7	20
31-40	6	17
41-50	13	37
51-60	4	11.4
Above 60	3	8.6
Total	**35**	**100**

4.2.1.2 Educational background of oyster mushroom marketers

The study revealed that 62.9% of the marketers had basic education, 22.8% had no formal education while 14.3% had secondary education. More so, none of them had tertiary education.

Table 4.15: Educational background of marketers

Education Level	Frequency	Percentage (%)
Non-formal	8	22.8
Basic	22	62.9
Secondary	5	14.3
Tertiary	0	0
Total	**35**	**100**

4.2.1.3 Religion of marketers

Among the marketers, Christians were the majority constituting 86% of the respondents and 14% were Muslims. None of the Traditional African Worshippers marketed mushrooms.

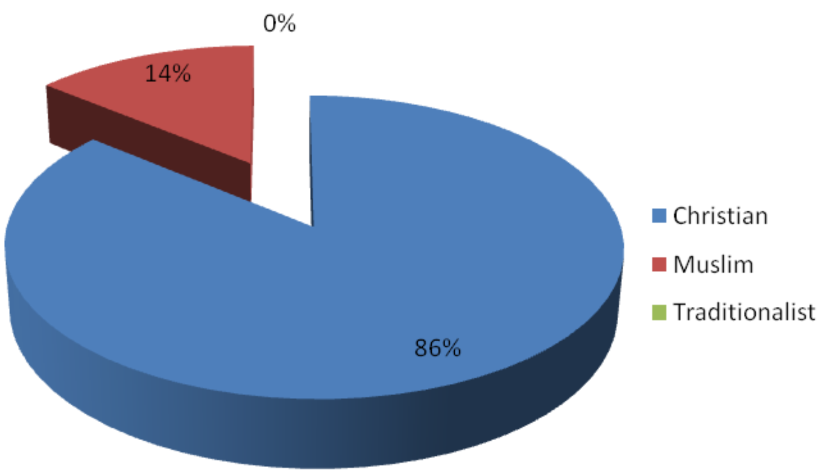


Figure 4.4: Religion of marketers

4.2.1.4 Number of years involved in the marketing of oyster mushroom The data gathered was to determine the impact of level of experience on the ability to better handle and preserve the mushroom for the market. The study indicated that 42.8% of the marketers had 1-3 years‟ experience in marketing the mushroom while 28.6% of the marketers had 4-6 years‟ experience in the business. Also, 20% and 8.6% respectively had been marketing mushroom for 7-9 years and 10-12 years.

Table 4.16: Number of years involved in the marketing of mushrooms

Number of years	**Frequency**	**Percentage (%)**
Less than 1 year	0	0
1-3 years	15	42.8
4-6 years	10	28.6
7-9 years	7	20
10-12 years	3	8.6
Above 12 years	0	0
Total	**35**	**100**

4.2.2 Level of Marketing of Oyster Mushroom in the Ho Municipality

Table 4.17 below showed that the majority (42.9%) of the marketers sold between 41-45kg mushrooms per week while 17.1% sold between 26-30kg mushrooms per week. Also, 11.4% marketed between 31-35kg mushroom per week and 8.6% each of the marketers sold between 21-25kg and 36-40kg mushrooms per week. In addition, 5.7% each of the marketers sold between 46-50kg and more than 50kg mushrooms. All the marketers (100%) sold the mushroom in both fresh and dried forms. The marketers packaged the mushrooms in white perforated low density polythene bags selling at GH¢4.00 per kg for fresh mushroom on bundle basis to consumers and GH¢6.00 per kg for dried mushroom.

Table 4.17: Level of marketing of oyster mushroom in the Ho Municipality

Quantity sold(kg/week)	Frequency	Percentage (%)
20 and below	0	0
21-25	3	8.6
26-30	6	17.1
31-35	4	11.4
36-40	3	8.6
41-45	15	42.9
46-50	2	5.7
Above 50	2	5.7
Total	**35**	**100**

4.2.3 Types of Mushroom Sold by the Marketers

The research revealed that 77% of the marketers had been selling oyster mushroom in combination with oil palm mushroom and a wild type referred to as *Termitomyces spp* locally known as "aforti" while 23% had been marketing only oyster mushrooms. The mushrooms were sold due to their availability and consumers" demand.

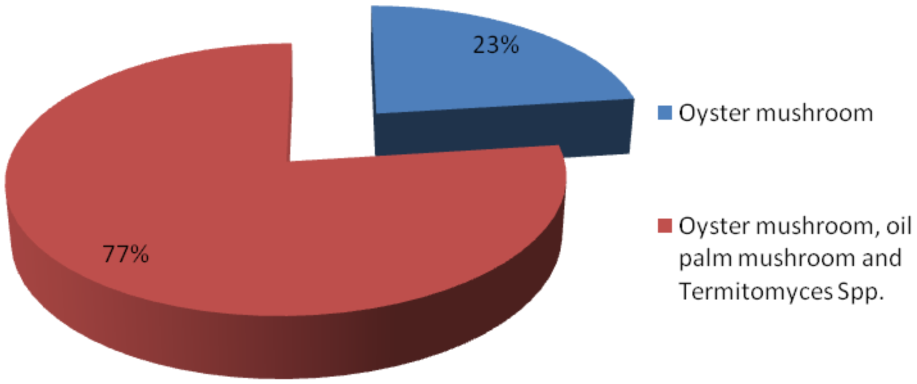


Figure 4.5: Types of mushroom sold by marketers

4.2.4 Level of Postharvest Losses of Oyster Mushroom at Marketing Level Experienced by the Marketers

Marketers experienced certain level of postharvest losses of oyster mushroom during marketing operations as indicated in Table 4.18 below.

Table 4.18: Level of postharvest losses at marketing level

Level of losses (%)	**Frequency**	**Percentage (%)**
1-5	3	8.6
6-10	6	17.1
11-15	10	28.6
16-20	4	11.4
21-25	5	14.3
26-30	7	20.0
Total	**35**	**100**

From Table 4.18 above, the research indicated that 28.6% of the marketers experienced losses between 11-15% during the marketing periods. Also, 20.0% of the marketers experienced losses between 26-30%, and 17.1% experienced losses between 6-10% while 14.3% experienced losses between 21-25% and 11.4% incurred losses between 16-20%. Only 8.6% experienced losses between 1-5%. However, the severity of losses of the mushrooms experienced by 28.6% of the marketers was high and estimated between 11-15% while the severity of losses encountered by 20.0% marketers was very high and was put at 26-30%. Again severity of losses encountered by few (8.6%) of the marketers was very low and was between 1-5%.

4.2.5 Level of Postharvest Losses of Oyster Mushroom Experienced by the Marketers during Storage Periods

Postharvest losses of oyster mushroom could not be avoided by the marketers. All (100%) of the marketers interviewed experienced certain amount of losses of the mushrooms during storage periods. Even though, there was a high demand for the products in the study area, the marketers still stored the mushrooms for future price increase. Each of them used refrigeration and drying methods which stored the mushrooms for 10-11 days and 1-2 months respectively (Appendix 1.10). Table 4.19 below showed the level of losses experienced by the marketers.

Table 4.19: Level of postharvest losses during storage periods by marketers

Level of losses (%)	Frequency	Percentage (%)
1-5	8	22.9
6-10	2	5.7
11-15	6	17.1
16-20	12	34.3
21-25	4	11.4
26-30	3	8.6
Total	**35**	**100**

As shown in Table 4.19 above, the data gathered indicated that 34.3% of the marketers experienced losses between 16-20%, 22.9% of them experienced losses between 1-5% and 17.1% had losses between 11-15%. Then, 11.4%, 8.6% and 5.7% experienced losses between 21-25%, 26-30% and 6-10% respectively. However, the severity of losses experienced by 34.3% of the oyster mushrooms marketers was high at 16-20% while severity of postharvest losses of the mushrooms experienced by few (8.6%) marketers was very high and was put at 26-30%. Then again, severity of losses encountered by 22.9% marketers was very low and was between 1-5% on storage.

4.2.6 Factors Contributing to Postharvest Losses of Oyster Mushroom at the Marketers' Level

The study showed that all (100%) of the marketers had ever experienced postharvest losses of mushroom during marketing periods. Table 4.20 below showed that in all, 37.1% of the marketers attributed the losses to exposure to heat especially during the dry season where they moved from place to place as hawkers while selling to the consumers and 28.6% of them mentioned lack of processing facilities that could change the fresh mushrooms to alternative form like mushroom powder and mushroom biscuits. Also, 22.9% of the marketers attributed the losses to inadequate storage facility while 11.4% of them attributed the losses to lack of organized market for mushrooms although the demand was high.

Table 4.20: Factors that contributed to postharvest losses at the marketers" level

Factors	Frequency	Percentage (%)
Exposure to heat	13	37.1
Lack of organized market	4	11.4
Lack of processing facilities	10	28.6
Inadequate storage facility	8	22.9
Total	**35**	**100**

4.2.7 Regression Analysis of Factors Contributing to Postharvest Losses at Marketers' level

As indicated in Table 4.21 below, at the marketer level, the model summary from the regression analysis revealed that number of years of experience in marketing of the mushrooms explained about 78.3% ($R^2 = 0.783$) of the variation in the losses recorded in marketing of mushroom. Other factors or causes include exposure of the mushroom to heat, lack of organized market for mushrooms, lack of processing facilities for mushrooms and inadequate storage facility for mushrooms (Table 4.20). The regression model is highly significant ($P<0.05$) therefore can be used for future prediction of storage losses at marketer level (Appendix 1.4). However, the value of beta coefficient B_1 is 1.406**.** Since $B_1 \neq 0$, there is enough evidence that number of years of experience was a major factor that contributed to postharvest losses of oyster mushrooms at the marketer level (Appendix 1.5).

Table 4.21: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.885[a]	.783	.776	.751

a. Predictors: (Constant), Number of years of experience

4.2.8 Problems Faced in Marketing of Oyster Mushroom

Figure 4.6 below indicted that 42.8% of the marketers had problem of rejection of deformed mushroom by consumers, 34.2% of them mentioned lack of organized market while 23% of the marketer mentioned storage problems during mushroom preservation.

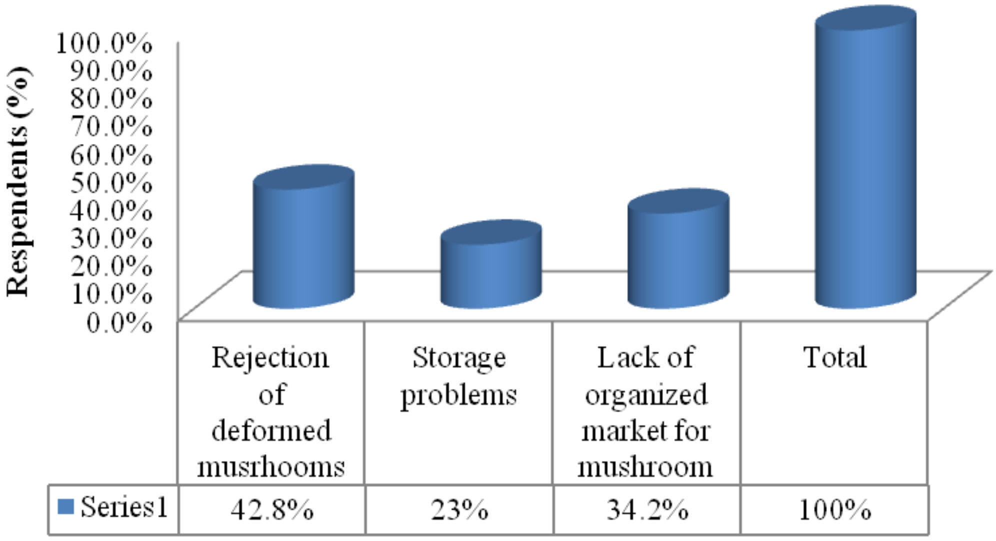


Figure 4.6: Problems faced in marketing oyster mushroom

4.3 CONSUMERS OF OYSTER MUSHROOM

4.3.1 Demographic Characteristics of Consumers

4.3.1.1 Age distribution of oyster mushroom consumers

From the study, it was realized that consumers who fell within 31-40 formed the majority (32%) while 20%, 7% and 5% fell in the 21-30, more than 60 years and 20 years and below age group respectively. Also, 18% of age group 41-50 and 51-60 years each also consume mushrooms.

Table 4.22: Age distribution of oyster mushroom consumers

Age group	Frequency	Percentage (%)
20 and below	4	5
21-30	14	20
31-40	23	32
41-50	12	18
51-60	12	18
Above 60	5	7
Total	**70**	**100**

4.3.1.2 Gender distribution of oyster mushroom consumers

The research revealed that out of 70 consumers interviewed, 59% of them were females while the males constituted 41%.

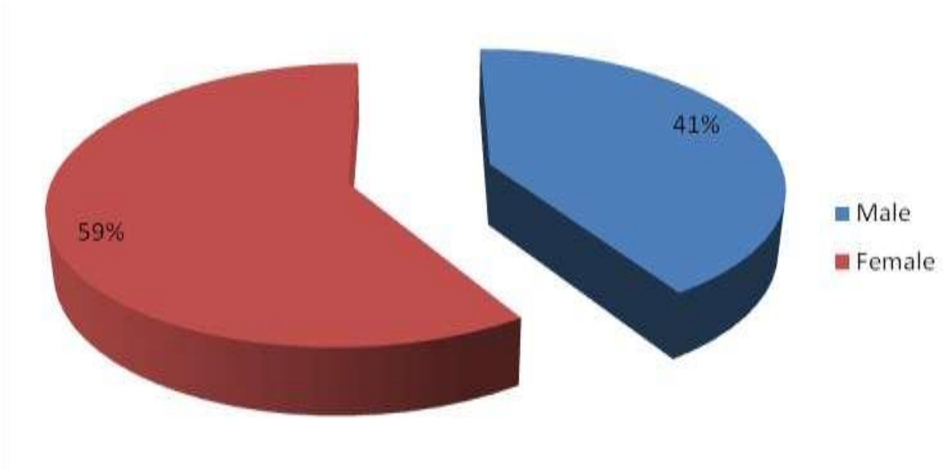


Figure 4.7: Gender distribution of oyster mushroom consumers

4.3.1.3 Educational background of oyster mushroom consumers

From the research as indicated in Table 4.23 below, it came light that 31.4% of the consumers interviewed had secondary education, 25.7% had tertiary education while 22.9% had basic education and 20.0% had no form of formal education.

Table 4.23: Educational background of consumers

Education Level	Frequency	Percentage (%)
Non-formal	14	20.0
Basic	16	22.9
Secondary	22	31.4
Tertiary	18	25.7
Total	**70**	**100**

4.3.1.4 Religion of oyster mushroom consumers

Among the consumers, Christians formed the higher percentage constituting 57% of the respondents and 17% were Muslims while 26% were Traditional African Worshippers that consumed the mushroom.

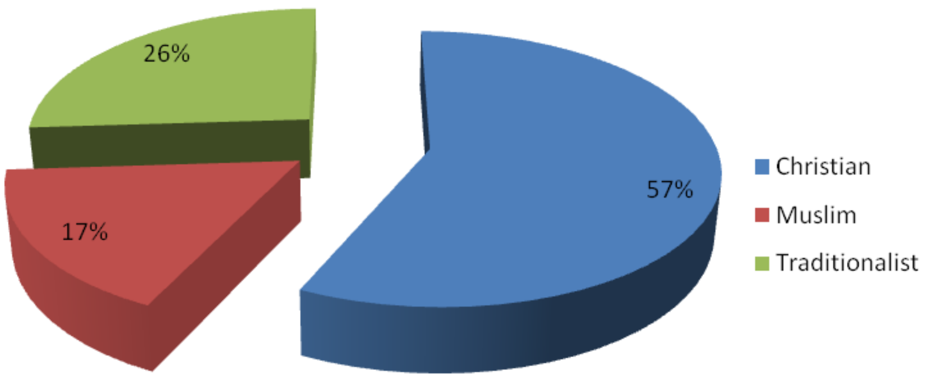


Figure 4.8: Religion of oyster mushroom consumers

4.3.1.5 Number of years involved in the consumption of oyster mushroom Table 4.24 below indicated number of years people were into consumption of oyster mushrooms in the study area.

Table 4.24: Number of years involved in the consumption of mushrooms

Number of years	Frequency	Percentage (%)
Less than 1 year	0	0
1-3 years	10	14
4-6 years	13	19
7-9 years	20	28
10-12 years	14	20
Above 12 years	13	19
Total	**70**	**100**

From Table 4.24 above, the survey showed that 28% of the consumers had been consuming mushrooms including oyster mushroom for 7-9 years and 20% had been consuming the mushrooms for 10-12 years while those who had been consuming mushrooms for 4-6 years and more than 12 years constituted 19% each. Those who had been consuming mushrooms for 1-3 years formed 14%. None of them had consumed mushrooms for less than 1 year.

4.3.2 Quantity of Mushrooms Purchased Per Week by Consumers

The data gathered showed in Table 4.25 below that 44.3% of the consumers of household size of 4-6 people purchased about 5-6kg mushroom per week while 34.3% of household size of 1-3 people purchased below 5kg mushroom per week. Also, 14.3% of household size of 7-9 people purchased about 7-8kg mushroom per week while 7.1% of household size of 10 people and above purchased about 9kg and above mushroom per week.

Table 4.25: Quantity of mushrooms purchased per week by consumers

Quantity of mushroom purchased kg/week	**Average Household**	**Frequency size**	**Percentage (%)**
Less than 5	1-3	24	34.3
5-6	4-6	31	44.3
7-8	7-9	10	14.3
9 and above	10 and above	5	7.1
Total		**70**	**100**

4.3.3 Level of Consumption of Oyster Mushroom per Week in the Study Area

Interaction with the consumers through interview as indicated in Table 4.26 below revealed that 44.3% had a household size of 4-6 people and consumed about 3-4kg mushroom per week while 34.3% had a household size of 1-3 people and consumed about 1-2kg mushroom per week. Also, 14.3% had a household size of 7-9 people and consumed about 5-6kg mushroom per week while 7.1% of those who had a household size of 10 people and above consumed about 7-9kg mushroom per week.

Table 4.26: Level of consumption of oyster mushroom per week in the study area

Quantity consumed (Kg/week)	Average Household Size	Frequency	Percentage (%)
1-2	1-3	24	34.3
3-4	4-6	31	44.3
5-6	7-9	10	14.3
7-9	10+	5	7.1
Total		**70**	**100**

4.3.4 Level of Postharvest Losses of Oyster Mushroom at Consumers Level

Table 4.27 below showed the level of postharvest losses experienced by consumers in the study area.

Table 4.27: Level of postharvest losses of oyster mushroom experienced by consumers

Level of losses (%)	Average household size	Frequency	Percentage (%)
1-5	1-3	24	44.3
6-10	4-6	31	34.3
11-15	7-9	10	14.3
16-20	10 and above	5	7.1
Total		**70**	**100**

The result above in Table 4.27 showed that 44.3% of the consumers experienced losses between 1-5% while 34.3% of them experienced losses between 6-10% and 14.3% experienced losses between 11-15% while 7.1% experienced losses between 16-20%. However, the severity of losses experienced by majority (44.3%) of consumers of average household size of 1-3 people was very low and was between 15% while severity of losses encountered by few (7.1%) of the consumers of average household size of 10 and above people was high and fell within 16-20%.

4.3.5 Factors Contributing to Postharvest Losses of Oyster Mushrooms at Consumers' Level

The study revealed that 45.7% of the consumers attributed the losses to dehydration of the mushrooms, 35.7% mentioned browning discolouration while 14.3% attributed the losses to texture changes and 4.3% mentioned that fluctuation of electricity also contributed to postharvest losses of the mushroom at storage in case of refrigeration method as shown in Table 4.28 below.

Table 4.28: Factors contributed to postharvest losses of oyster mushroom at consumers" level

Factors	Frequency	Percentage (%)
Texture changes	10	14.3
Browning discolouration	25	35.7
Dehydration	32	45.7
Fluctuation of electricity	3	4.3
Total	**70**	**100**

4.3.6 Regression Analysis of Factors Contributed to Postharvest Losses at consumers' level

The model summary from the regression analysis indicated in Table 4.29 below revealed a major contributing factor to postharvest losses of oyster mushroom at the consumers" level.

Table 4.29: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.959 [a]	.920	.919	.270

a. Predictors: (Constant), Method of storage

The model summary in Table 4.29 above showed that storage methods practiced by the consumers (Appendix 1.10) explained about 92% ($R^2 = 0.920$) of the variation in the losses recorded in mushroom storage at the consumer level. Other factors or causes include texture changes, browning discolouration, dehydration and fluctuation of electricity (Table 4.28). The regression model is highly significant ($P < 0.05$) and therefore can be used for future prediction of storage losses of mushroom at the consumer level (Appendix 1.7). However, the value of beta coefficient $B_{1,}$ is 0.891. Since $B_1 \neq 0$, there is enough evidence that storage method was a major contributing factor to postharvest losses of oyster mushroom at the consumer level (Appendix 1.8).

4.3.7 Reasons for Mushroom Consumption in the Ho Municipality

Mushrooms for food may be cooked fresh after harvesting or first dried. Fresh mushrooms are washed and cut into small pieces before being used in the preparation of stew or soup. The data gathered from the study conducted showed that various reasons were given for mushroom consumption as indicated in Table 4.30 below.

Table 4.30: Reasons for mushroom consumption in the Ho Municipality

Reasons	Frequency	Percentage (%)
Tasty delicacy	16	22.9
Nutritional values	25	35.7
Medicinal values	20	28.6
Texture	2	2.8
Meat and fish substitute	4	5.7
Availability of mushrooms	3	4.3
Total	**70**	**100**

Table 4.30 above revealed that the majority (35.7%) of consumers had been consuming mushroom due to it nutritional values and 28.6% of them had been consuming

mushroom because of its medicinal values. Also, 22.9% of the consumers said they consumed the mushroom because of its tasty delicacy, 5.7% of them consumed mushroom as a substitute of meat and fish while 4.3% and 2.8%
respectively consumed mushroom as a result of its availability and texture.

4.3.8 Consumers' Perception about Nutrients in Oyster Mushroom and its Medicinal Importance

4.3.8.1 Consumers' perception about nutrients in oyster mushroom

The study showed that 45.7% of the consumers said that the mushroom contains protein, 31.4% stated minerals while 22.9% mentioned vitamins.

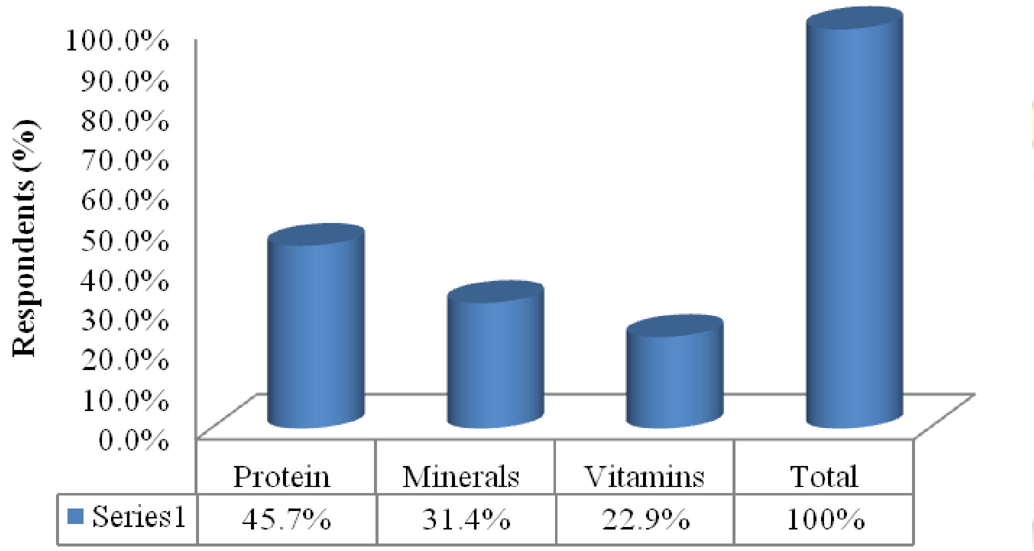


Figure 4.9: Consumers‟ perception about nutrients in oyster mushroom

4.3.8.2 Consumers' perception about medicinal importance of oyster mushroom

Information gathered from the research indicated that consumers knew certain ailment that consumption of mushrooms could prevent as indicated in Table 4.31 below.

Table 4.31: Consumers‟ perception about medicinal importance of oyster mushroom

Ailments	**Frequency**	**Percentage (%)**
Diabetes	35	50
Hypertension	15	21.4
Weight-Watchers	20	28.6
Total	**70**	**100**

From Table 4.31 above, it was revealed that 50% of the consumers said that oyster mushroom consumption could prevent diabetes while 28.6% said that the mushroom consumption could reduce fatness therefore good for weight-watchers and 21.4% of them mentioned that consumption of oyster mushroom could prevent hypertension.

4.4 SUMMARY OF POSTHARVEST LOSSES IN OYSTER MUSHROOM PRODUCTION IN THE HO MUNICIPALITY

The result of the study as shown in Table 4.32 below revealed the state of postharvest losses of oyster mushroom production from the producers through the marketers to the consumers and therefore unearthed the average postharvest losses of oyster mushroom in the municipality.

Table: 4.32: Summary of postharvest losses in oyster mushroom production in the Ho municipality

Respondents	**Range of losses (%)**	**Average losses (%)**
Producers:		
(i) On the farm	6 -10	8
(ii)During postharvest handling operations	6 – 10	8
Sub-total	**<u>12-20</u>**	**<u>16</u>**
Marketers:		
(i)During marketing	11 – 15	13
(ii)On storage	16 – 20	18
Sub-total	**<u>27-35</u>**	**<u>31</u>**
Consumers		
	1 – 5	3
Total	**40-60%**	**50%**

Table 4.32 above indicated that majority (50%) of the producers at farm level and majority (66.6%) of the producers during postharvest handling operations (Table 4.8 and 4.9) respectively experienced average loss between 12-20% and to that effect, the severity of losses was high while majority (28.6%) of the marketers during marketing periods and 34.3% at storage level (Table 4.18 and 4.9) respectively experienced

average loss between 27-35% and in such a situation, the severity of losses was very high. Also, majority (44.3%) of the consumers (Table 4.27) experienced losses between 1-5% in that the severity of losses was very low. The range of postharvest losses of oyster mushroom in the Ho Municipality was between

40-60% and to that effect, the severity of losses was very high.

4.5 LABORATORY WORK

4.5.1 Percentage Weight Losses of Oyster Mushrooms Treated with Combinations of Temperature and Packaging Materials and Packaged at Different Packaging Hours after Harvest and Stored in a Refrigerator and at Room temperature

Table 4.33 below showed the interaction effect of all treatments to which the oyster mushrooms were subjected to. It therefore, revealed percentage weight losses of oyster mushrooms treated with combinations of temperatures together with different packaging materials and at varied packaging hours after harvest and stored in a refrigerator and at room temperature.

Table 4.33 Percentage weight losses of mushrooms treated with combinations of temperatures and packaging materials and at varied packaging hours after harvest and stored (*Weight loss is presented as Mean ± Standard Deviation*; *Bowl = Transparent Plastic Bowl; Polythene = Perforated Polythene Bag; * = Mushroom samples had gone past shelf life and had been disposed)*

Treatment Time	**Storage Methods**	**Packaging Materials**	**Storage Duration (days)**		
			2	**5**	**8**
Immediately After Harvest	**Room Temperature Temp/RH.; 24^{0}C/87%**	**Polythene**	4.05 ± 2.19	*0.00 ± 0.00	*0.00 ± 0.00
		Bowl	39.04 ± 6.01	89.15 ± 4.42	*0.00 ± 0.00
	Refrigerator Temp/RH.; 2-3^{0}C/8-10%	**Polythene**	1.77 ± 1.29	7.67 ± 0.47	14.51 ± 4.71
		Bowl	12.79 ± 1.70	56.31 ± 3.78	80.07 ± 1.00
12 Hours After Harvest	**Room Temperature Temp/RH.; 30^{0}C/61%**	**Polythene**	5.10 ± 1.09	*0.00 ± 0.00	*0.00 ± 0.00
		Bowl	23.78 ± 8.16	90.19 ± 4.65	*0.00 ± 0.00
	Refrigerator Temp/RH.; 2-3^{0}C/8-10%	**Polythene**	0.83 ± 0.54	13.02 ± 9.09	26.79 ± 19.01
		Bowl	14.28 ± 1.50	57.04 ± 1.37	81.57 ± 0.26
24 Hours After Harvest	**Room Temperature Temp/RH.; 25^{0}C/85**	**Polythene**	12.40 ± 6.70	*0.00 ± 0.00	*0.00 ± 0.00
		Bowl	31.46 ± 14.23	*0.00 ± 0.00	*0.00 ± 0.00
	Refrigerator Temp/RH.; 2-3^{0}C/8-10%	**Polythene**	4.74 ± 0.77	14.16 ± 0.96	*0.00 ± 0.00
		Bowl	13.25 ± 6.60	52.07 ± 7.09	85.83 ± 0.36

Table 4.33 above revealed that by the second day of post-treatment, oyster mushroom samples that had been packaged into perforated polythene bags immediately after harvest and kept at an average room temperature of 24^0C with 87% relative humidity had lost approximately 4% of their initial weight and had reached their shelf-life before the fifth day. Oyster mushroom samples that had been packaged into opened transparent plastic bowls and kept at an average room temperature of 24^0C with 87% relative humidity, however, lost more weight (approximately 39%) compared to oyster mushroom samples that had been packaged into perforated polythene bags. By the fifth day however, these mushrooms had lost more than half of their initial weight (89%) and reached their shelf life before the eighth day of post-treatment.

Generally, oyster mushroom samples that were kept at room temperatures lost more of their weights than replicates that had been stored in a refrigerator. For example, oyster mushroom samples that had been packaged into perforated polythene bags and kept at room temperature of 24^0C with 87% relative humidity had lost approximately twice the amount of weight of oyster mushroom samples that had been stored in a refrigerator at 2-3^0C (approximately 2%). Oyster mushroom samples that had been packaged into perforated polythene bags and stored in a refrigerator also had longer shelf-lives than oyster mushroom samples kept at room temperatures. That is by the eighth day of posttreatment, oyster mushroom samples kept at refrigeration temperature at 2-3^0C with 810% relative humidity remained usable while those kept at room temperature of 24^0C with 87% relative humidity had attained their shelf-lives by the fourth to fifth day of post treatment.

Oyster mushrooms samples treated with perforated polythene bags and stored in a refrigerator at 2-3^{0}C with 8-10% relative humidity had lost approximately 2% of their initial weights by the second day after treatment and continued to remain usable until the eighth day after treatment by which time they had lost approximately 15% of their initial weights. Oyster mushroom packaged into opened transparent plastic bowls and stored in a refrigerator at 2-3^{0}C had lost more weight (approximately 13%) than those kept in perforated polythene bags by the second day after treatment and continued to lose weight even up to the eighth day after treatment. A similar trend of weight loss was recorded for treatments that were replicated twelve hours and twenty-four hours after harvest (Table 4.33).

However, by the second day of post-treatment, oyster mushroom samples that had been packaged into perforated polythene bags 12 hours after harvest and kept at an average room temperature of 30^{0}C with 61% relative humidity had lost approximately 5% of their initial weight and had reached their shelf life before the fifth day while oyster mushroom samples that had been packaged into opened transparent plastic bowls 12 hours after harvest and kept at room temperature of 30^{0}C with 61% relative humidity lost approximately 24% weight. By the fifth day, however, these mushroom samples had lost more than half of their initial weight (approximately 90%) to end their postharvest life. Nonetheless, oyster mushrooms packaged into perforated polythene bags 12 hours after harvest and stored in a refrigerator at 2-3^{0}C with 8-10% relative humidity on the second day of post-treatment lost initial weight of 0.83% and also approximately 13% and 27% weight loss on the fifth and eighth day respectively. Also, oyster mushroom samples packaged into opened transparent plastic bowls and stored in a refrigerator at 2-3^{0}C by the second day of post-treatment lost initial weight approximately 14%. Also, the mushrooms lost approximately 57 % and 82% cumulative weight on the fifth and eighth day respectively (Table 4.33).

Furthermore, oyster mushrooms that had been packaged into perforated polythene bags 24 hours after harvest and kept at room temperature of 25^{0}C with 85% relative humidity by the second day of post-treatment lost initial weight approximately 12% while oyster mushrooms packaged into opened transparent plastic bowls and kept at the same temperature lost initial weight approximately 31%. However, oyster mushroom samples that had been packaged into perforated polythene bags 24 hours after harvest and stored in a refrigerator at 2-3^{0}C by the second day of post-treatment lost initial weight approximately 5% and further lost 14% on the fifth day. Besides, oyster mushroom samples that had been packaged into opened transparent plastic bowls and stored in a refrigerator at 2-3^{0}C with 8-10% by the second day of post-treatment lost initial weight approximately 13%. Also, the mushrooms lost approximately 52% and 86% cumulative weight on the fifth and eighth day respectively (Table 4.33). This trend translated into cumulative weight loss by the end of the experiment as shown in Figure 4.10 below.

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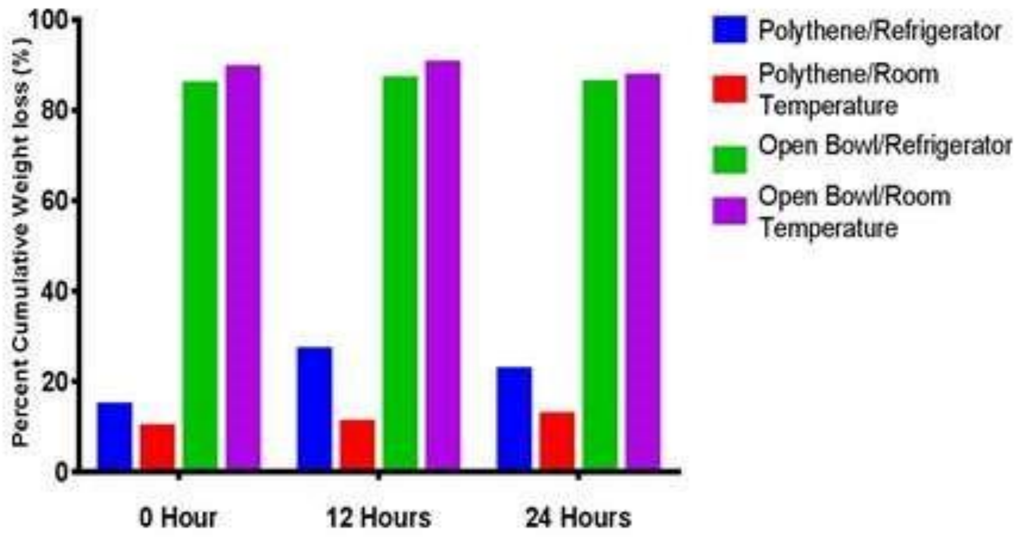


Time of treatment after harvesting (Hours)

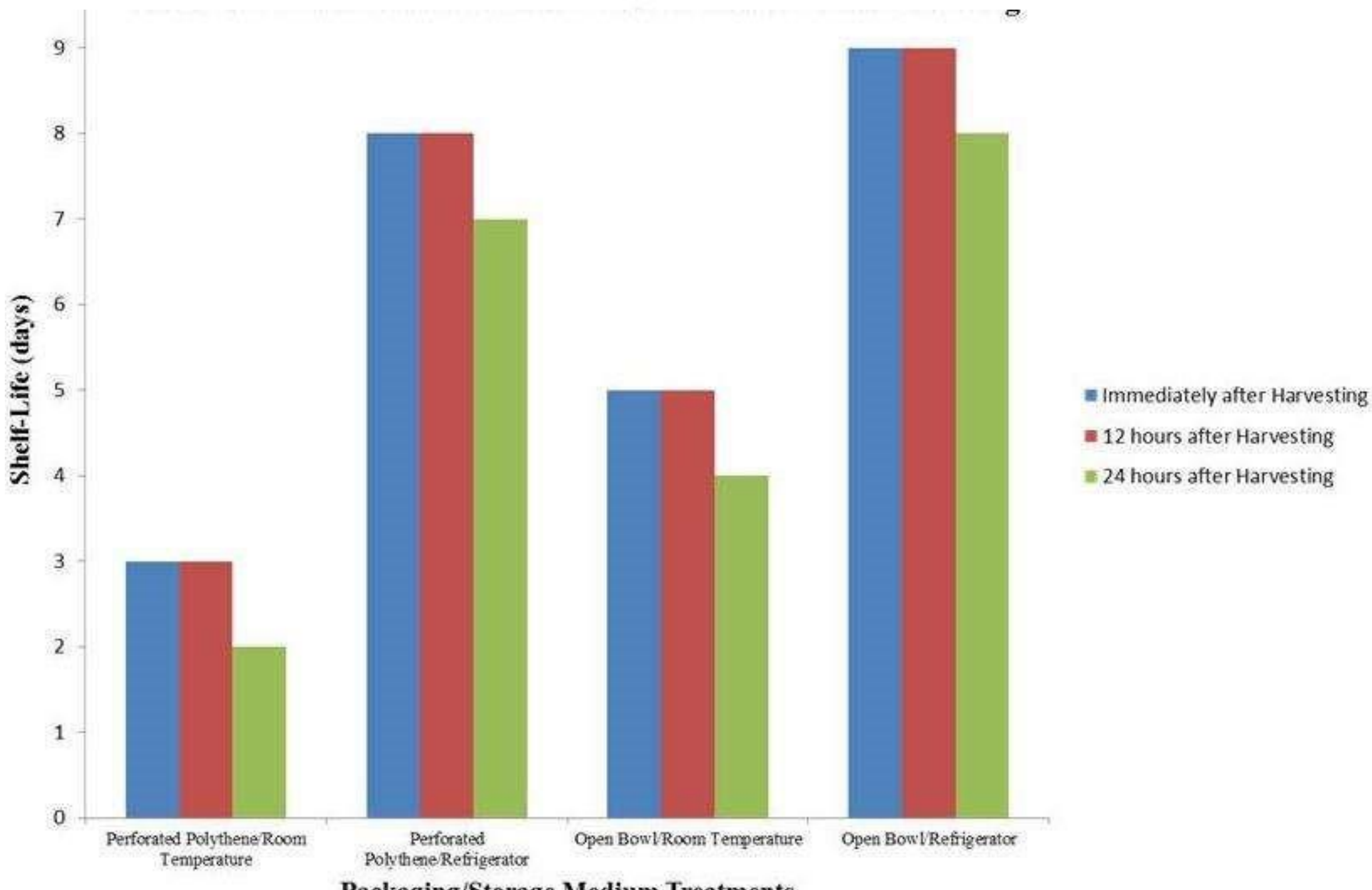
Figure 4.10: Effects of four combinations of temperatures and packaging materials treatments on cumulative weight loss in mushrooms immediately after harvest, 12 hours and 24 hours after harvest.

4.5.2 Multiple Comparisons of Treatments

All post-hoc comparisons revealed that when temperature was kept constant and packaging materials were varied among treatments that were conducted at the same time, there was significant weight loss while on the other hand when packaging materials were kept constant and temperature was varied among treatments there was no significant resultant weight loss among oyster mushroom samples (Appendix 1.13). The only other striking observation from analysis of the post-hoc tests was that samples that were packaged into perforated polythene bags immediately after harvest and stored in a refrigerator at 2-3^{0}C with 8-10% relative humidity lost significantly different weights from those that were treated similarly 12 hours after harvest (Appendix 1.14). Since the degree of significance was weak for the comparison of weight loss for the same treatment at 0 hour and 12 hours and that such a trend was not observed for treatments that were even conducted at 24 hours after harvest, it is very likely that any observed difference in weight loss might have been due to an error in the application of the treatment.

4.5.3 Effect of Treatments on Shelf Life of Mushrooms after Harvest

The Figure 4.11 below showed the effect of treatments on the shelf life of oyster mushrooms after harvest.



Shelf-Life (days)
0
1
2
3
4
5
6
7
8
9
Perforated Polythene/Room Temperature
Perforated Polythene/Refrigerator
Open Bowl/Room Temperature
Open Bowl/Refrigerator
Packaging/Storage Medium Treatments
Immediately after Harvesting
12 hours after Harvesting
24 hours after Harvesting

Treatments

Figure 4.11 Effects of treatments on shelf life of mushrooms after harvest.

Figure 4.11 above indicated that generally, oyster mushroom samples that were stored under refrigeration conditions had longer shelf-lives (7-9 days) than those that were stored at an average room temperature of 30^0C (2-5 days). Samples that were treated with perforated polythene bags and stored at an average room temperature of 30^0C with 61% relative humidity had the shortest shelf-lives while those that were packaged into opened transparent plastic bowls and stored in a refrigerator at 2-3^0C with 8-10% relative humidity had the longest shelf-lives with firm texture. Shelflives of oyster mushroom samples were also shorter when they were treated 24 hours after harvest than when they were treated immediately after harvest and 12 hours after harvest.

Colour change in mushrooms is an indicator of quality loss that leads to deterioration and eventually contributes to postharvest losses of the mushrooms. With the aid of a colour wheel and chart, (Appendix 4), it was observed that irrespective of packaging materials used, time of packaging of the mushrooms and storage methods practiced for the experiments, at the end of the storage periods, the grey colour of oyster mushrooms had changed. The grey colour changed to orange colour for mushrooms packaged into perforated polythene bags and opened transparent plastic bowls and stored in a refrigerator at 2-3^0C with 8-10% relative humidity after 9 days. However, samples that were subjected to the same treatment but stored at room temperature showed orange colour with dark spots (5 days).

It was observed that the texture of the oyster mushrooms felt soft when touched and smelled rancid for samples packaged into perforated polythene bags and plastic bowls 24 hours after harvest and stored at room temperature after 2 days. Also, slimy spots developed on the mushrooms that were packaged into perforated polythene bags and opened transparent plastic bowls and stored at room temperature.

5.0 DISCUSSION

5.1 FIELD SURVEY

5.2 OYSTER MUSHROOM PRODUCERS

5.2.1 Demographic Characteristics of Producers

The majority (36.7%) of the oyster mushroom producers fell within the age group of 31-40 years (Table 4.1). This could be attributed to the fact that work on mushroom cultivation requires a great deal of energy and dedication that can be provided by the active youth than the aged. Oei (1991) reported that mushroom production is a difficult task involving many steps, from selecting a suitable technique and strain to spawn manufacturing, growing the crop and marketing the final product and therefore, the activities of mushroom production are undertaken mostly by active and dedicated people probably due to the fact that active working group being the bread winners decided to go into mushroom production as an income generating activity in order to support their families as it has impacts on their livelihood.

The production of oyster mushroom in the study area was male dominated with 63% (Figure 4.1).This is because, the production activities were tedious and time consuming and therefore require much more energy which can be provided by the men than the women. The nature of the activities discourages more women from getting actively involved in mushroom production. Sawyerr (1991) reported that mushroom production involves much more activities such as composting, sterilization of the substrates, bagging with sawdust, watering, pests and diseases control and more so during the production period much attention is paid to cleanliness of the production house as diseases thrive in an unclean house. After two months of flushing, all the compost bags are removed and sprayed with 2.5kg of fresh neem seeds or leaves and mixed with 15 litres of water. The neem seeds or leaves are pounded, mixed with water and strained. The mixture is left to stand overnight and it is used to spray the cropping house.

Majority of the producers that formed 93.3% had formal education and held basic, secondary and tertiary qualifications with a few not having any formal education (Table 4.2). Oyster mushroom production required some degree of understanding of some basic principles involved in the production and the educational background of the producers made them appreciate these principles of mushroom production better especially when it comes to management practices that could contribute to higher yield and the appropriate time of harvesting to reduce losses. Also, they could understand and handle challenges better than those with little or no formal education. Sawyerr (1991) reported that the mushroom cropping house needs to be provided with adequate ventilation, aeration and light in order to obtain good quality mushrooms at the time of harvest coupled with higher yield. The best time to harvest is when the cap begins to emerge from the veil and it is best done in the morning. According to Oei (1991), stumps of harvested mushrooms are not left for soft rot bacteria and green mould to grow on, as the left over portion would decay and spread to succeeding crop causing a drastic reduction in yield due to disease infections.

5.2.2 Quantity of Oyster Mushroom Bags Raised in the Production House

Majority (40%) of the producers had between 1001-1500 oyster mushroom bags in their production house with a few (6.7%) having more than 3000 oyster mushroom bags in their production houses (Table 4.6). The reason why most of the producers had between 1001-1500 oyster mushroom bags in the production house might be due to financial constraints (Table 4.12) that contributed to their inability to raise much oyster mushroom composted bags as it is done elsewhere, even though, they had the desire to produce more of the mushrooms. Actually, mushroom production requires great deal of energy and it is labour intensive and therefore needs a lot of dedication and commitment. However, it was observed that a few (6.7%) of them who had raised more than 3000 bags might have had financial support and farm hands which helped them in carrying out certain production activities such as composting, sterilization of the substrates, bagging, spawning and watering. This enabled such producers who had the zeal to raise large quantity of oyster mushroom bags to increase production since the enterprise had impact on their livelihood.

5.2.3 Level of Production of Oyster Mushroom per Week in the Ho Municipality

With the level of production of oyster mushrooms (as indicated in Table 4.7), majority (43.3%) of the producers produced about 41-50kg mushrooms per week with a few (6.7%) producing more than 60kg mushrooms per week in the study area. The production in the Ho Municipality seemed to be low due to lack of financial support (Table 4.12) to raise much oyster mushroom composted bags and to carry out production practices with hired labour in order to produce large quantity of oyster mushrooms. Also, low production of the mushroom could be attributed to high cost of input like mushroom spawn and climatic problem (Table 4.12). It might also be due to lack of technical know-how and expertise since mushroom production requires technical knowledge in order to attain higher level of production. According to Bempah (2011), BemCom Youth Association of Techiman in the Brong Ahafo region raises about 3,700 to 4,500 oyster mushroom bags in a week and therefore produced large quantities of mushroom per week.

5.2.4 Level of Postharvest Losses in Oyster Mushrooms at the Producers' Level

Postharvest losses of the mushroom occurred at the producers‟ level on the farm and during postharvest handling operations. The level of losses at the producers‟ level in both instances fell in the range between 12-20% (Table 4.32). Table 4.8 indicated that on the farm, the majority (50%) of the producers interviewed experienced losses between 6-10% and to this effect it could be said that the severity of losses on the farm was low while 23.3% of them experienced losses between 21-25% and a few (3.3%) of them experienced losses between 26-30% and with this, it could be argued that the severity of losses was very high. Kumah and Olympio (2009) reported that 20-80% of fresh produce are lost after harvest in the tropics and subtropics. These losses could be attributed to extreme temperatures, physical damage, wrong harvesting time, inappropriate harvesting technique, pests and diseases infestations. According to Rai and Arumuganathan (2008), mushrooms contain about 90% moisture therefore; exposing them to high temperatures could result to rapid dehydration of the entire structure which contributes to loss in quality. Ares *et al.* (2007) also reported that dehydration causes economic losses to mushroom producers and also influences their deterioration rate.

The producers also experienced losses of the mushroom during postharvest handling operations. The majority (66.6%) of the producers experienced losses between 610% during postharvest handling operations (Table 4.9). It could be argued that the severity of this level of losses (6-10%) was low. The losses were attributed to poor handling operations such as sorting and packaging where the produce developed unattractive brown colour. In addition, it was also observed that storing the mushrooms at unsuitable refrigeration temperatures could result to losses during postharvest handling operations. The Food and Fertilizer Technology Centre (2007) reported that out of 17 million metric tonnes of perishables produced in Japan in 1991, there was a 10% loss during postharvest handling. According to Jayathunge and Illeperuma (2004), physiological disorders are the main causes of postharvest losses of mushrooms. The disorders are mainly caused by slow handling of the mushrooms which enhances opening and darkening of the gills, wilting of the entire structure and brown discolouration of the cap and stem.

5.2.5 Factors Contributing to Postharvest Losses of Oyster Mushroom at Farm Level

The results in Table 4.10 indicated that majority (33.3%) of the producers considered high moisture content of mushroom as one of the influential factors that contributed to postharvest losses of the mushroom. As a result of high moisture content of mushrooms, they could rapidly lose water and easily be attacked by microbes. A reduction in moisture content would result in wilting due to dehydration and subsequent deterioration. Ares *et al.* (2007) reported that water loss from growing mushroom is comparable to that from a free water surface since 90% of mushroom weight at harvest is water and therefore dehydration causes economic losses to mushroom producers and influences their deterioration rate.

Other factors identified included postharvest changes such as wilting, browning and opening of gills, pests and diseases infestations, environmental conditions and metabolic factors (Table 4.10). According to Fonseca *et al.* (2002), fresh mushrooms are metabolically active for long periods after harvesting and therefore their respiration rate determines the deterioration rate and onset of senescence in cultivated mushrooms.

The regression analysis (Table 4.11) however, revealed that time of harvesting of the mushrooms by the producers was a major contributor to the postharvest losses of the oyster mushroom in the study area including other factors or causes such as postharvest changes, metabolic factors and high moisture content (Table 4.10). The study revealed that majority (70%) of producers harvested in the morning when the marketers had not arrived and this contributed to a delay in purchasing the mushrooms. It could be argued that metabolic activities had been taking place until the produce were disposed of and this could create room for postharvest changes like brown colouration and dehydration of the mushroom structure. Again, 23.3% had no specific time for harvesting and 6.7% of them harvested in the afternoon (Table 4.13). It was observed that harvesting in the afternoon exposed the harvested mushrooms to high temperatures which caused wilting and dehydration of the produce and brown discolouration which made the mushrooms unwholesome and unsaleable. According to Ares *et al.* (2007), mushrooms quick deterioration is mainly caused by their high metabolic activity, respiration rate and dehydration due to high temperatures.

5.2.6 Problems Faced by Oyster Mushrooms Producers

The producers of oyster mushrooms recounted many problems notable among them was lack of financial support (100%) as indicated in Table 4.12 from financial institutions and Non-Governmental Organizations. It could be deduced that financial institutions were not willing to advance credit facilities to the producers due to uncertainties of the output dynamic.

The study revealed that input like mushroom spawns were expensive such that the producers could not raise much composted bags of the oyster mushrooms as it is done elsewhere (Table 4.12). According to Bempah (2011), BemCom Youth Association of Techiman in the Brong Ahafo region raises about 3,700 to 4,500 oyster mushroom bags in a week. Mushroom production is tedious and therefore needed hired labour to carry out certain production activities such as composting, bagging, sterilization of the substrates and spawning the composted bags at a cost.

During bumper harvest, the producers tried to store some of the mushrooms and sell them at a future date for a higher price. But storage problems (Table 4.12) such as inadequate storage facilities and lack of storage technology made it difficult for them to store the mushrooms for a longer duration. Agyei *et al*. (1993) reported that inadequate storage facilities do not allow farmers to maintain some kind of food security. Adequate storage and suitable facilities are required to make it possible to store produce including mushrooms under appropriate conditions for long periods of time. It was observed that due to inadequate storage facilities for mushrooms, the producers were very anxious to dispose of their produce soon after harvest to minimize postharvest losses. This might result in price fluctuations and instability in the marketing of the produce.

5.3 MARKETERS OF OYSTER MUSHROOM

5.3.1 Demographic Characteristics of Marketers

The majority (37%) of marketers fell within 41-50 years age group in the marketing of the oyster mushrooms and a few (6%) of them fell within 20 and below age group (Table 4.14). Marketing especially with wholesale business requires strenuous effort that can be provided by the active marketers. Agyei *et al*. (1993) reported that marketing constitutes all the processes, facilities and services involved in putting the goods and services into suitable or acceptable forms for the benefit of both the seller and consumer. These activities therefore require much energy and dedication. The research conducted revealed that only females were involved in the marketing of oyster mushroom in the Ho Municipality. This was attributed to the fact that business of selling is undertaken in towns and cities by market women that control the market and determine the market prices of produce and therefore can better handle perishable produce. The women were into selling of mushrooms to contribute to family incomes. Ninfaa (2011) reported that women are experts in the use, processing and marketing of vegetables including mushrooms. This is because, these are essential resources to sustain the family and ensure good health of the household. Business of selling is an economic venture for people, especially women having little capital, limited access to land and working under labour constraints. The incomes derive from this enterprise contribute significantly to food security at the household level and enable women to attain a degree of financial independence within the family budget. Business women play an important supportive role by providing access to skills development in operations, management and marketing and market information.

The study revealed that majority (77.2%) of the marketers had formal education and held basic and secondary qualifications and 22.8% of them had no formal education

(Table 4.15). Marketing and storage of perishable produce like oyster mushroom require some degree of understanding of some basic principles of marketing functions. The educational background of the marketers could make them understand the marketing system of mushroom business and appreciate principles of marketing functions. Fialor (2011) reported that marketing is more than just selling therefore requires some level of educational background to understand the marketing system. Market system performs several functions of which some of them include storage, packaging, distribution, risk bearing, standardization and market intelligence.

5.3.2 Level of Marketing of Oyster Mushrooms in the Ho Municipality As indicated in Table 4.17, majority (42.9%) of the marketers sold between 41-45kg mushrooms per week with a few (5.7%) each of them marketed between 46-50kg and more than 50kg mushrooms per week. The level of marketing in the Municipality seemed to be low since there was no secure market for mushrooms in the Municipality. Therefore, the marketers moved from one place to another in the course of selling the mushrooms. It was observed that this nature of marketing discouraged the marketers from selling large quantities of mushrooms to avoid postharvest damages to the produce that could eventually contribute to postharvest losses since the level of perishability of mushrooms is very high. Also, inadequate storage facilities (Table 4.20) discouraged the marketers to sell mushrooms in large quantities since unpatronized mushrooms could not have a place for storage. However, Bempah (2011) reported that BemCom Youth Association of Techiman in the Brong Ahafo Region sells 50kg mushrooms per day.

The marketers packaged the mushrooms in white perforated low density polythene bags selling at GH¢4.00 per kg for fresh mushrooms on bundle basis to consumers and GH¢6.00 per kg for dried mushroom. The marketers said that they preferred using the white low density perforated polythene bags as packaging materials because, this kind of material could prevent heat accumulation in the pack and therefore could minimize the rate of deterioration during the marketing periods.

5.3.3 Level of Postharvest Losses in Oyster Mushrooms at the Marketers Level

The marketers of oyster mushroom experienced certain level of postharvest losses of the produce during marketing operations and storage periods. The range of losses in both instances fell within 27-35% (Table 4.32). The severity of the losses between 27-35% was very high. The research indicated that majority (28.6%) of the marketers experienced losses between 11-15% which was high during marketing periods and a few (2.8%) of them also experienced losses between 1-5% (Table 4.18). It could be argued that the severity of losses between 1-5% was very low. The level of losses was attributed to lack of organized market for mushrooms and as a result, the marketers moved from one place to another with the produce on their head as hawkers under the hot sun. It was observed that this system of marketing contributed to severe wilting, dehydration, discolouration and texture changes of the mushrooms. These changes resulted to losses in quality and quantity of the mushrooms. The Food and Fertilizer Technology Centre (2007) reported that during the process of marketing and distribution of produce, substantial losses are incurred which range from a slight loss of quality to total spoilage. Postharvest losses may occur at any point in the marketing process, from the initial harvest through assembly and distribution to the final consumer. The causes of losses can be due to physical damage during handling, physiological decay, water loss or sometimes simply because there is a surplus in the market place and no buyer can be found.

The marketers sometimes stored the mushrooms when there is abundance in the market and later released them into the market for the consumers. They used refrigeration and drying methods which stored the mushrooms for 10-11 days and 12 months respectively (Appendix 1.10). On storage, majority (34.3%) incurred losses between 16-20% and a few (5.7%) of them experienced losses between 6-10% (Table 4.19). These losses could be attributed to inadequate storage facilities (Table 4.20) and might also be due to lack of storage techniques as asserted by the Ho Municipal Planning Committee Unit (2011) that postharvest losses have come about because of the general lack of knowledge about preservation techniques and inadequacy of appropriate processing and storage facilities.

Mushroom browning is an important cause of loss of quality during postharvest storage. According to Nerya *et al*. (2006), browning of mushroom occurs as a result of two distinct mechanisms of Phenol oxidation and spontaneous oxidation. As a result of senescence, cell membranes are disrupted and compartmentalization is lost allowing enzymes and substrates to mix thereby accelerating browning. Ares *et al. (*2007) reported that mushroom loss of firmness during postharvest storage is due to changes in membrane.

5.3.4 Factors Contributing to Postharvest Losses of Oyster Mushroom at Marketers' Level

As indicated in Table 4.20, majority (37.1%) of the marketers attributed the loss factor during marketing periods to exposure of the mushrooms to heat especially during the dry season where the marketers moved from one place to another as hawkers while selling the produce to the consumers since there was no secure market for mushrooms as mentioned by 11.4% of the consumers. As a result, this nature of marketing contributed to dehydration of the mushrooms as asserted by Maalekuu (2008) that water loss in perishable produce equals to loss of saleable weight and contributes to a direct loss in marketing. Also, 28.6% of the marketers mentioned lack of processing facilities for mushrooms. These facilities if available could process fresh mushrooms to alternative forms like mushroom powder and mushroom biscuits. This value addition could minimize the rate of deterioration and also place a premium on mushrooms for the marketers and induce the consumers to buy them. In addition, 22.9% of the marketers attributed the postharvest losses to inadequate storage facilities and this sometimes compelled them to store the fresh mushrooms with other volatile perishable produce in the same storage facility like refrigerator and this could contribute to deterioration of the mushrooms.

The regression analysis (Table 4.21) however, revealed that number of years of experience by the marketers in marketing the mushrooms was a major contributor to postharvest losses of the oyster mushrooms in the Ho Municipality at the marketers level including other factors or causes such as exposure of the mushrooms to heat, lack of organized market for mushrooms, inadequate storage facilities and lack of processing facilities (Table 4.20). The study however, showed in Table 4.16 that 42.8% of the marketers had between 1-3 years‟ experience and on the average; the level of postharvest losses of oyster mushroom in Ho Municipality was put at 50% (Table 4.32). This implies that majority of the marketers were inexperienced in handling the harvested mushrooms to minimize losses as asserted by Fialor (2011) that marketing is more than just selling and therefore involves several functions such as assembling, storage, packaging, distribution, risk bearing, standardization and market intelligence. It is important for a marketer to have experience to handle these marketing functions effectively in order to minimize losses.

5.3.5 Problems Faced in Marketing of Oyster Mushroom

Figure 4.6 indicated that majority (42.8%) of the marketers of oyster mushroom had a problem with the rejection of deformed mushrooms by the consumers due to postharvest damages. Lack of organized market for mushrooms was a worry to the marketers (34.2%) as they usually moved from one place to another in the course of selling the mushrooms under the scorching sun. This nature of marketing exposed the fresh harvested mushrooms to heat especially during the dry season. A repeated exposure to fluctuating temperatures resulted in wilted mushrooms which could not be patronized by the consumers. The marketers (23%) also had problem with storage such as inadequate storage facilities and lack of storage techniques and therefore could not store the produce for a longer duration during bumper harvest where there was excess in supply into the market. According to the Food and Fertilizer Technology Centre (2007), postharvest losses can ensue when there is a surplus of produce in the market due to inadequate storage facilities and where no buyer can be found.

5.4 CONSUMERS OF OYSTER MUSHROOM

5.4.1 Demographic Characteristics of Consumers

Majority (32%) of consumers fell within 31-40 years age group and a few (7%) of them were above 60 years age group (Table 4.22).The consumers consumed mushrooms for various reasons. The majority (35.7%) of consumers said that they consumed oyster mushroom because of its nutritional values and 28.6% of them consumed the mushroom due to its medicinal importance. Also, 22.9% consumed the mushroom due to its tasty delicacy. A few of them consumed the mushroom as a substitute of meat and fish (Table 4.30). Oei (1991) reported that mushrooms are considered to be healthy because of their relatively high and qualitatively good protein content, low fat content, vitamins and minerals. In Ghana, mushroom is consumed as tasty meat-substitute and is consumed to prevent diabetes and hypertension due to its low fat content (Sawyerr, 1991).

The study revealed that majority (59%) of females interviewed consumed oyster mushroom and 41% males also consumed the mushroom (Figure 4.7). This showed that females consumed mushroom more than the males in the Municipality. This was attributed to the fact that women consider mushroom as a vegetable and as an ingredient in soup and stew and therefore consumed much of the mushroom due to its tasty delicacy. It was observed that they consumed the mushroom due to its nutritional and medicinal importance. Gary *et al*. (2003) reported that in the United State, men and women consume mushrooms in exactly the same proportion as their shares of the population. Men account for 49% of the population and reported consuming 49% of all mushrooms while women account for 51% of the population and reported consuming 51% of all mushrooms.

Majority (80%) of the consumers had formal education and held basic, secondary, and tertiary qualifications with a 20% of them not having any formal education (Table 4.23). The educational background of the consumers made them better understand the nutritional and medicinal values of mushrooms and therefore consumed them. Sawyerr (1991) reported that mushrooms contain nutritional and medicinal properties therefore are healthy for consumption.

5.4.2 Level of Consumption of Oyster Mushroom per Week in the Study Area

Majority (44.3%) of the consumers had a household size of 4-6 people and consumed about 3-4kg mushroom per week with a few (7.1%) of them had a household size of 10 and above people and consumed about 7-9kg mushroom per week (Table 4.26). The consumers consumed the mushroom due to its nutritional and medicinal importance (Table 4.30). The level of consumption could be attributed to the household size of the consumers since the larger the household size, the higher the level of consumption. Bempah (2011) reported that in Ghana, people who understand the value and like the delicate flavour of oyster mushroom consumed about 1kg per week for those who purchased them at a price of GH¢4-GH¢6 per kg.

The act of consuming mushrooms dates to ancient time. The Chinese value mushrooms for medicinal properties as well as for food (Wikipedia 2011). Fresh market consumption in the United States was 3.36868×10^8kg in 2001-2002. On any given day, nearly 10% of Americans consume mushrooms in some form (Gary *et al.*, 2003).

5.4.3 Level of Postharvest Losses in Oyster Mushroom at the Consumers Level

Postharvest losses of oyster mushroom also occurred at home level. This is because, not all the quantity that was purchased was consumed immediately. The result of the study showed that majority (44.3%) of the consumers experienced losses between 15% and 34.3% of them also experienced losses between 6-10% while few others that formed 7.1% experienced losses between 16-20% (Table 4.27). The severity of losses at 16-20% was high. This was attributed to texture changes of the mushroom, browning, dehydration and fluctuation of electricity during storage (Table 4.28). It could also be attributed to the storage methods practiced by the consumers such as refrigeration, smoking, salting and drying methods (Appendix1.10) which could preserve the mushroom for only few number of days except for drying method that could preserve the mushroom up to 1-2 months. It could also be due to inadequate storage facilities and lack of preservation techniques for mushrooms. The Food and Fertilizer Technology Centre (2007) reported that levels of home losses of perishables may be low at certain places but high elsewhere, e.g. in Korea, level of home losses for perishables estimated at 42% for water melon.

In lieu of inadequate storage facilities, consumers stored the mushrooms together with other volatile perishables of high respiratory rate. Also, it was observed that about 60% of the consumers stored the mushrooms at ambient condition which contributed to dehydration and microbial spoilage. Rai and Arumuganathan (2008) reported that as mushrooms contain high moisture and delicate in texture, they cannot be stored for more than 24 hours at the ambient condition of the tropics.

5.4.4 Factors Contributing to Postharvest Losses of Oyster Mushrooms at Consumers Level

The data gathered from the study as indicated in Table 4.28, revealed factors that contributed to postharvest losses of oyster mushroom in the Ho municipality. The majority (45.7%) of consumers attributed the loss factor to dehydration of the mushroom after harvest even on storage due to unsuitable storage temperatures.

Mushrooms moisture content is high and therefore, the rate at which moisture is lost from the produce is very high. Ares *et al.* (2007) reported that freshly harvested mushrooms transpire at a fast rate. Also, 35.7% of the consumers mentioned browning of the mushroom structure. The brown discolouration of the mushroom made it unwholesome. This occurred as a result of exposure of the mushrooms to heat (Table 4.20). According to Ares *et al. (*2006), browning occurs as a result of two distinct mechanisms of phenol oxidation and spontaneous oxidation. In addition, 14.3% of the consumers attributed the loss factor to texture changes which contributed to deterioration of the mushroom. Postharvest senescence in perishables is accompanied by changes in cell membrane characteristics which lead to loss of barrier function and loss of turgor (Ares *et al.,* 2007). The texture changes of mushroom contributed to postharvest losses.

However, the regression analysis (Table 4.29) revealed that storage methods used by the consumers were the major contributors to postharvest losses of the oyster mushrooms at consumers" level in the study area including other factors or causes such as texture changes, browning discolouration, dehydration and fluctuation of electricity (Table 4.28). The study showed that majority (42.9%) of the consumers used refrigeration storage method, while 28.5% of them used drying method, 20% used salting and a few of them practiced smoking method. All these methods could store the fresh mushrooms well for only few number of days except drying method which even causes weight losses due to dehydration (Appendix 1.10). The storage methods made it difficult for the consumers to prolong the storage life of the mushrooms. It was however, observed that the refrigeration method was faced with a problem like power outage that caused postharvest damages such as texture changes and browning discolouration to the mushrooms even on storage.

5.5 LABORATORY STUDIES

5.5.1 Effect of Combinations of Temperature, time of packaging, Packaging Materials and storage methods on Percentage Weight Loss in Oyster Mushrooms

The trends in weight loss at an average room temperature of 30^0C with 61% relative humidity may most possibly be accounted for by rapid water loss in mushrooms when exposed to a combination of other factors such as atmospheric pressure, temperature of ambient air and high relative humidity of the storage environment. It could also be attributed to high metabolic activities of the mushrooms, packaging materials and temperature of the storage environment. According to Kumah and Olympio (2009), water loss in perishables leads to weight loss and other consequent attributes such as wilting, loss of appearance and texture. Severe wilting can be induced by storage for even less than 24 hours under hot dry conditions.

The weight loss that was observed for mushrooms kept in perforated polythene bags was also indicative of a very plausible restriction or retardation of the rate of water loss and therefore, showed a possible strong association and or causation between packaging materials and weight loss (Appendix 1.13). A similar study by Maalekuu (2008) demonstrated that high relative humidity is essential to prevent desiccation and loss of glossiness. Type of Packaging materials and storage methods used for the storage of the oyster mushrooms could also have influenced moisture loss.

According to Jayathunge and Illeperuma (2005), packaging oyster mushrooms in 0.015mm linear-low density polythene packages with 3g of MgO after washing with 0.5% CaCl and 0.5% citric acid can extend the shelf life of oyster mushroom from 6-12days. Zanderighi (200l) also reported that mushrooms have high respiration rates and require packaging film with oxygen and carbon dioxide permeability. Micro and macro perforated films are suitable for use as packaging materials. These are required due to occurrence of anaerobic conditions and physiological damage as a result of high carbon dioxide concentrations. Also polythene is extremely chemical resistant, making it suitable as packaging materials. During storage, film packaging retards weight loss, deterioration, texture changes and discolouration.

Ares *et al.* (2007) had reported that water loss from growing mushroom is comparable to that from a free water surface since 90% of mushroom weight at harvest is water and therefore freshly harvested mushrooms transpire at the same rate as the fruiting sporophore. Dehydration causes economic losses to mushroom producers, marketers and consumers and also influences their deterioration rate. Mushrooms lost large quantity of water soon after harvest and this contributed to dehydration of mushrooms structure. Epidermal layer of mushrooms does not prevent a quick superficial dehydration that causes important quality loss. Therefore, dehydration causes weight loss of mushrooms and affects their shelf life.

The short postharvest life could also be due to heat build-up and condensation of moisture within the perforated polythene bags. It was observed that at a certain stage of the storage, the mushrooms smelled rancid; an indicator that determines the end of shelf life. It was also observed that there were accumulation of moisture in the polythene bags due to heat build-up even though they were perforated. This therefore, contributed to softening of the mushroom structure as asserted by Brennan and Gormely (1998) that spoiled mushroom is identified when smell of ammonia or smell rancid, soft to touch and had slime spots on its structure. Oyster mushrooms packaged into opened transparent plastic bowls experienced high amount of weight loss (Table 4.33) due to their larger surface area. Fresh mushrooms are metabolically active for long periods after harvest. Therefore, the large surface area of the packaging materials might have contributed to the high weight loss of the mushrooms since the greater the surface area the higher the rate of respiration of the produce in storage.

5.5.2 Effect of Treatments on Shelf Life of Oyster Mushrooms after Harvest

Weight loss is a function of shelf life. In other words, the results of the treatments on weight loss translate directly to how long oyster mushroom samples remained viable for consumption. As mentioned earlier, Jayathunge and Illeperuma (2005) observed that packaging material of 0.015mm linear low-density polyethylene packages with 3g of magnesium oxide after washing with 0.5% calcium chloride and 0.5% citric acid can extend the postharvest life of oyster mushrooms at $8^{o}C$ and 70% relative humidity from 6 days in commercial samples to 12 days.

Shelf-lives of oyster mushroom samples were also shorter (2 days), although not significantly, when they were treated 24 hours after harvest than when they were treated immediately after harvest and 12 hours after harvest. This could be attributed to high respiration rate of mushrooms when exposed to the atmosphere as demonstrated by Ares *et al.* (2007). According to Maalekuu (2008), water loss equates to loss of saleable weight, and thus constitutes a direct loss in marketing.

Colour change in mushrooms is an indicator of quality loss and that had affected the shelf life. It was observed that irrespective of packaging materials used, time of packaging of the mushrooms and storage methods, during the storage period, the grey colour of oyster mushrooms had changed. The grey colour changed to orange colour for mushrooms packaged into perforated polythene bags and opened transparent plastic bowls and stored in a refrigerator at 2-3^{0}C after 9 days. However, samples that had been packaged into perforated polythene bags and opened transparent plastic bowls but stored at an average room temperature of 28^{0}C showed orange colour with dark spots (5days) by the use of colour wheel and chart (Appendix 4). Villaescusa and Gil (2003) reported that one of the main changes associated with oyster mushroom deterioration during postharvest storage is change in colour and the occurrence of soft and spongy texture, due to cell growth and water migration. High texture losses and discolouration to yellow colour can occur after 7 days of storage at 4°C and 7°C.

It was also observed that irrespective of packaging materials used, time of packaging, and storage methods carried out, the texture of the oyster mushrooms felt soft when touched. Also, slimy spots developed on the mushrooms that were packaged into perforated polythene bags and opened transparent plastic bowls and kept at an average room temperature of 30^{0}C with 61% relative humidity and began to smell rancid of ammonia on the third day and fifth day respectively. Ares *et al*. (2007) reported that one of the main changes associated with oyster mushrooms deterioration is changes in their texture. Postharvest senescence in a variety of horticultural commodities is accompanied by changes in cell membrane characteristics, which leads to loss of barrier function and loss of turgor. Mushrooms softening or loss of firmness during postharvest storage has been ascribed to changes in membrane. According to Villaescusa and Gil (2003), high texture losses can occur after 7 days of storage at 4°C and 7°C and the occurrence of soft and spongy texture, is due to cell growth and water migration.

6.0 SUMMARY, CONCLUSIONS AND RECCOMENDATIONS

6.1 SUMMARY

A research was undertaken to assess the postharvest losses in oyster mushroom production in the Ho Municipality. The majority (40%) of the producers had between 1001 – 1500 oyster mushrooms composted bags in their production houses and 6.7% raised more than 3000 oyster mushrooms composted bag in the municipality and produced more than 60kg mushrooms per week. As a result of high demand of the mushrooms 42.9% of the marketers sold about 41-45kg mushroom per week and 5.7% sold more than 50kg mushrooms per week. Due to nutritional and medicinal values and delicacy of the mushroom, 44.3% of the consumers of house size of 4-6 people consumed as much as about 3-4kg mushroom per week and few (7.1%) of them of household size of more than 10 people consumed as much as 7-9kg mushrooms per week.

Result of the study revealed that majority of the producers at farm level (50%) and during postharvest handling operations (66.6%) experienced loss between 12-20% due to postharvest changes of the mushrooms, high moisture content of the mushrooms and time of harvesting. Also, 28.6% of the marketers during marketing operations and 34.3% of the marketers during storage periods encountered loss between 27-35% due to exposure to heat during marketing, lack of organized market and inadequate storage facility. However, the majority (44.3%) of the consumers encountered loss between 1-5% since much of the quantity that was purchased, was consumed, therefore, less loss was experienced. The average postharvest losses of oyster mushroom in the Ho Municipality (from the producers, marketers and consumers) ranged between 40-60%. It could be argued that this level of postharvest loss of oyster mushrooms regarding its severity in the Municipality, was very high. The preferred mushrooms consumed in the Municipality were oyster mushroom, oil palm mushroom and *Termitomyces* spp.

The regression analysis revealed that time of harvesting of the mushrooms, number of years of experience of marketing the mushrooms and storage methods were the major contributing factors or causes to postharvest losses of oyster mushrooms in the Ho Municipality as their beta coefficient is not equal to zero. Major problems affecting oyster mushroom production included lack of financial support, high cost of spawn and labour, storage problem and postharvest changes of the produce. Major problems facing the mushroom marketers were rejection of deformed mushrooms and lack of organized market for the harvested mushrooms.

Majority of producers (93.3%), marketers (77.2%) and consumers (80%) had formal education. Oyster mushroom production in the Ho Municipality was male dominated (63%). The majority (36.7%) of oyster mushroom producers fell within the age group of 31-40 years while majority (37%) of the marketers fell within the age group of 41-50 years and majority (32%) of the consumers fell within 31-40 years age group. White low density perforated polythene bags were the main packaging materials in the Ho Municipality.

The laboratory study revealed that oyster mushroom samples that were kept at room temperature lost more of their weights than replicates that had been stored in a refrigerator. For example, oyster mushroom samples that had been packaged into perforated polythene bags and kept at room temperature of 24^0C with 87% relative humidity had lost approximately twice the amount of weight of oyster mushroom samples that had been stored in a refrigerator at 2-3^0C with 8-10% relative humidity (Table 4.33). Oyster mushroom samples that had been stored in a refrigerator at 23^0C also had longer shelf-lives of 9 days than oyster mushroom samples kept at room temperature of 2 days (Figure 4.11). All post-hoc comparisons revealed that when temperature was kept constant and packaging materials were varied among treatments that were conducted at the same time, there was significant weight loss while on the other hand when packaging materials were kept constant and temperature was varied among treatments there was no significant resultant weight loss among oyster

mushroom samples (Appendix 1.13). These comparisons suggest a possible strong association and or causation between packaging materials and weight loss of mushrooms and that temperature differences might have had little effect on their weight loss. The only other striking observation from analysis of the post-hoc tests was that samples that were packaged into perforated polythene bags immediately after harvest and stored in a refrigerator at 2-3^{0}C lost significantly different weights from those that were treated similarly 12 hours after harvest
(Appendix 1.14).

6.2 CONCLUSIONS

The study has shown that demand for mushrooms was relatively strong and therefore appears to be growing in the Ho Municipality. This includes the demand for specialty mushrooms such as oyster mushroom which was the main type of mushroom produced in the Municipality. The majority (40%) of the producers had between 1001 – 1500 oyster mushrooms composted bags in their production houses and (43.3%) of them produced about 41-50kg oyster mushrooms per week. Also, majority of marketers (42.9%) sold about 41-45kg mushroom per week and majority of consumers (44.3%) consumed about 3-4kg mushroom per week.

With regards to losses, producers experienced average loss of 16%, whereas, the marketers lost as much as 31% and the consumers encountered only 3% loss. Therefore, average of postharvest losses of oyster mushroom from producers, markers and consumers was put at 50%.

The regression analysis revealed that time of harvesting of the mushrooms, number of years of experience of marketing the mushrooms and storage methods were the major contributing factors or causes to postharvest losses of oyster mushrooms in the Ho Municipality. Other factors included high moisture content of mushrooms, postharvest changes, poor storage technology, exposure to heat, lack of processing facilities, inadequate storage facilities, texture changes, brown discolouration and dehydration.

The study revealed that oyster mushrooms packaged into perforated polythene bags immediately after harvest and stored in a refrigerator at $2\text{-}3^{0}C$ with 8-10% relative humidity retarded weight loss significantly and extended the shelf life to 8-9days. It was observed that oyster mushroom samples packaged into opened transparent

plastic bowls immediately after harvest and stored in a refrigerator at $2\text{-}3^{0}C$ with 810% relative humidity had firm texture till the ninth day. After 8 days, the grey colour changed to orange colour for mushrooms packaged into perforated polythene bags while samples in opened transparent plastic bowls changed the grey colour to orange colour after 9 days when stored in a refrigerator at $2\text{-}3^{0}C$ with 8-10% relative humidity. However, samples that were subjected to the same treatment but stored at room temperature showed orange colour with dark spots (5 days).

6.3 RECOMMENDATIONS

To make oyster mushroom production more viable in the Ho Municipality, the following are recommended:

- Harvesting of oyster mushroom should be done in the morning to reduce postharvest losses.
- The producers should form co-operative society to help one another by raising funds to increase production.
- Provision of adequate and effective storage facilities to reduce postharvest losses of the mushroom in the municipality.
- There is the need to research into appropriate storage facilities and adopt suitable postharvest storage technology in order to minimize postharvest losses of the oyster mushroom especially at the marketer level.
- There should be intensive education on preservation techniques to the producers, marketers and consumers of the mushroom.
- Oyster mushroom should be packaged immediately into perforated polythene bags after harvest and stored in a refrigerator to reduce weight loss.
- Oyster mushroom should not be allowed to stay up to 24 hours before packaging for storage.
- Mushrooms should not be stored at room temperatures.

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APPENDICES

APPENDIX 1

Table 1: ANOVA table for regression analysis for postharvest loss at producer level

Model	Sum of Squares	df	Mean Square	F	Sig.
1 Regression	33.779	1	33.779	33.515	.000[a]
Residual	28.221	28	1.008		
Total	62.000	29			

a. Predictors: (Constant), Time of harvest

b. Dependent Variable: % loss

Table 2: Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
1 (Constant)	2.508	.316		7.931	.000
TIME OF HARVEST	.844	.146	.738	5.789	.000

a. Dependent Variable: % loss

Table 3: Excluded Variables[b]

Model	Beta In	T	Sig.	Partial Correlation	Collinearity Statistics
					Tolerance
1 Level of losses during postharvest handling operation by producers.	-.123[a]	-.374	.711	-.072	.156
Period of production	-.226[a]	-.586	.563	-.112	.112

a. Predictors in the model: (Constant), Time of harvest

b. Dependent Variable: % loss

Table 4: ANOVA table for regression analysis for postharvest loss at marketers level

Model	Sum of Squares	df	Mean Square	F	Sig.
1 Regression	66.945	1	66.945	118.787	.000[a]
Residual	18.598	33	.564		
Total	85.543	34			

a. Predictors: (constant), years of experience

b. Dependent Variable: Quantity lost during storage

Table 5: Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
	B	Std. Error	Beta		
1 (Constant)	1.583	.281		5.638	.000
YEARS OF EXPERIENCE	1.406	.129	.885	10.899	.000

a. Dependent Variable: Quantity lost during storage

Table 6: Excluded Variables[b]

Model	Beta *In*	t	Sig.	Partial Correlation	Collinearity Statistics
					Tolerance
1 Postharvest damage	.127[a]	-.374	1.463	.250	.848

a. Predictors in the model: (Constant), Years of experience

b. Dependent Variable: Quantity lost during storage

Table 7: ANOVA table for regression analysis for postharvest loss at consumer level

Model	Sum of Squares	df	Mean Square	F	Sig.
1 Regression	53.831	1	53.831	740.210	.000[a]
Residual	4.654	64	.073		
Total	58.485	65			

a. Predictors: (Constant), Method of storage
b. Dependent Variable: percentage (%) storage losses

Table 8: Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
1 (Constant)	.120	.072		1.672	.099
Method of storage	.891	.033	.959	27.207	.000

a. Dependent Variable: Percentage (%) storage losses

Table 9: Excluded Variables[b]

Model	Beta In	t	Sig.	Partial Correlation	Collinearity Statistics
					Tolerance
1 Storage duration	.[a]				.000
Postharvest changes	.046[a]	1.239	.220	.154	.914

a. Predictors in the Model: (Constant), Method of storage

b. Dependent Variable: Percentage (%) storage losses

Table 10: Storage methods of mushroom practiced in the study area

Storage method	Producer		Marketers		Consumer		Shelf life
	Freq	Percent (%)	Freq	Percent (%)	Freq	Percent (%)	
Refrigeration	30	100	35	100	30	42.9	8 -10
Drying	30	100	35	100	20	28.5	1-2 months
Salting	0	0	0	0	14	20	7-8 days
Smoking	0	0	0	0	6	8.6	5-6 days

Total	30	100	35	100	70	100	________-

Table 11: Duration for maturity

Duration	Frequency	Percentage
21 - 25 days	9	30.0
26 - 30 days	21	70.0
Total	30	100.0

Table 12: Number of times of harvest

Number of harvest per week	Frequency	Percentage (%)
2 - 3 DAYS 3	28	93.3
- 4 DAYS	2	6.7
Total	30	100.0

Table 13: Post-hoc Turkey‟s multiple comparisons of treatments within treatment times.

Tukey's multiple comparisons test	95% CI	Significant?	Summary
0 Hours			
PR vs. PT	-11.18 to 20.73	No	ns
PR vs. BR	-86.96 to -55.04	Yes	****
PR vs. BT	-90.59 to -58.68	Yes	****
PT vs. BR	-91.73 to -59.82	Yes	****
PT vs. BT	-95.37 to -63.46	Yes	****
BR vs. BT	-19.59 to 12.32	No	ns
12 Hours			
PR vs. PT	0.1441 to 32.06	Yes	*
PR vs. BR	-75.82 to -43.91	Yes	****
PR vs. BT	-79.35 to -47.44	Yes	****
PT vs. BR	-91.92 to -60.01	Yes	****
PT vs. BT	-95.45 to -63.54	Yes	****
BR vs. BT	-19.49 to 12.43	No	ns
24 Hours			
PR vs. PT	-6.019 to 25.89	No	ns

PR vs. BR	-79.46 to -47.54	Yes	****
PR vs. BT	-80.90 to -48.99	Yes	****
PT vs. BR	-89.39 to -57.48	Yes	****
PT vs. BT	-90.84 to -58.93	Yes	****
BR vs. BT	-17.40 to 14.51	No	ns

CI = Confidence Interval, * = Level of Significance, PR = Perforated Polythene Bag and Refrigerator Treatment, PT = Perforated Polythene bag and Room Temperature Treatment, BR = Opened Transparent Plastic Bowl and Refrigerator Treatment, BT = Opened Transparent Plastic Bowl and Room Temperature Treatment, 0 hour = Treatments immediately after Harvest, 12 hours = Treatments done 12 hours after harvest, 24 hours = Treatments done 24 hours after harvest, ns = not significant.

Table 14: Post-hoc Turkey‟s multiple comparisons of treatments between treatment times.

Tukey's multiple comparisons test	**95% CI**	**Significant?**	**Summary**
PR			
0 Hours vs. 12 Hours	-21.27 to -3.306	Yes	**
0 Hours vs. 24 Hours	-16.80 to 1.161	No	ns
12 Hours vs. 24 Hours	-4.514 to 13.45	No	ns
PT			
0 Hours vs. 12 Hours	-9.944 to 8.017	No	ns
0 Hours vs. 24 Hours	-11.64 to 6.321	No	ns
12 Hours vs. 24 Hours	-10.68 to 7.284	No	ns
BR			
0 Hours vs. 12 Hours	-10.13 to 7.831	No	ns
0 Hours vs. 24 Hours	-9.301 to 8.661	No	ns
12 Hours vs. 24 Hours	-8.151 to 9.811	No	ns

BT			
0 Hours vs. 12 Hours	-10.02 to 7.937	No	ns
0 Hours vs. 24 Hours	-7.111 to 10.85	No	ns
12 Hours vs. 24 Hours	-6.067 to 11.89	No	ns

CI = Confidence Interval, * = Level of Significance, PR = Perforated Polythene Bag and Refrigerator Treatment, PT = Perforated Polythene bag and Room Temperature Treatment, BR = Opened Transparent Plastic Bowl and Refrigerator Treatment, BT = Opened Transparent Plastic Bowl and Room Temperature Treatment, 0 hour = Treatments immediately after Harvest, 12 hours = Treatments done 12 hours after harvest, 24 hours = Treatments done 24 hours after harvest, ns = not significant.

Table 15: Repeated Measures ANOVA.

2way AVOVA Tabular results		**A**	**B**	**C**	**D**
		Data Set-A	Data Set-B	Data Set-C	Data Set-D
		Y	**Y**	**Y**	**Y**
1	Table Analyzed	Two-way ANOVA with RM by column			
2					
3	Two-way RM ANOVA	Matching: Stacked			
4	Alpha	0.05			
5					
6	Source of Variation	% of total variation	P value	P value summary	Significant?
7	Interaction	0.3514	0.2281	ns	No
8	Time	0.1886	0.1152	ns	No
9	Column Factor	96.94	< 0.0001	****	Yes
10	Subject (matching)	1.911	0.0009	***	Yes
11					
12	ANOVA table	SS	DF	MS	F (DFn, DFd)
13	Interaction	168.0	6	27.99	F (6, 16) = 1.541
14	Time	90.17	2	45.08	F (2, 16) = 2.481
15	Column Factor	46341	3	15447	F (3. 8) = 135.3
16	Subject (matching)	913.7	8	114.2	F (8, 16) = 6.285
17	Residual	290.7	16	18.17	
18					
19	Number of missing values	0			

Column Factor = Percent Weight Loss

APPENDIX 2:

SAMPLE QUESTIONNAIRE ADMINISTERED TO PRODUCERS, MARKETERS AND CONSUMERS

Kwame Nkrumah University of Science and Technology, Faculty of Agriculture Department of Horticulture

Questionnaire on Postharvest Losses in Oyster Mushroom Production in the Ho Municipality of the Volta Region of Ghana

QUESTIONNAIRE FOR PRODUCERS

(A). SOCIAL BACKGROUND OF RESPONDENTS

1. Name…………………………………………………………………………….
2. Age: 20 and below [ ] 21-30 [ ] 31-40 [ ] 41-50 [ ] 51-60 [ ] 60+ [ ]
3. Gender: Male [ ] Female [ ]
4. Educational status…………………………………………………………..

(i) Basic [ ] (ii) Secondary [ ] (iii) Tertiary [ ] (iv) Non-formal [ ] (v) Others [ ] specify ....

5. Occupation………………………………………………………………………….
6. Religion…………………………………………………………………………
7. Hometown……………………………………………………………………….. 8. Residential Area……………………………………………………………….

9. Social Status…………………………………………………………………………..

(B) MUSHROOM PRODUCTION

1a. Do you produce mushrooms? YES [ ] NO [ ]

1b. If YES, what type do you produce? Oyster mushroom [ ] button mushroom [ ] oil palm mushroom [ ] others [ ] (specify)………………………………………………..

2a.Which method(s) do you use for the production? Indoor [ ] outdoor [ ] others [ ] (specify)…………………………………………………………

2b. Where do you obtain your spawn? Extension agents [ ] FRI [ ] Amateur spawn producers [ ] others [ ] (specify)……………………………………

3a. How many years have you been producing the mushrooms? < 1 year [ ] 1-3 years [ ] 4-6 years [ ] 7 -9 years [ ] 10-12 years [ ] more than 12years [ ]

(specify)……………………………………………

3b. Which seasons of the year do you mostly produce the mushrooms? All year round [ ] Rainy season [ ] [ ] Dry season [ ] others [ ]

(specify)…………………………

3c.Which substrate(s) do you use for the production? Sawdust [ ] Agriculture wastes [ ] wood shaving [ ] others [ ]

(specify)……………………………………………

4a.How long does it take for the mushrooms to reach maturity for harvesting after spawning? 14-20days [ ] 21-25days [ ] 26-30days [ ] others [ ]

(specify)………………

4b. How frequent do you harvest mature mushroom? 2-3 days [ ] 3-4days [ ] 4-5 days [ ] others [ ]

(specify)…………………………………………………………...

4c. How many bag of mushroom do you have in your production house?

< 500bags [ ] 500-1000 bags [ ] 1001-1500 bags [ ] 1501-2000 bags [ ] 2001-3000 bags [ ] above 3000bags [ ]

4d.What time of the day do you harvest the mushrooms? Morning [ ] Afternoon [ ] evening [ ] others [ ]

(specify)………………………………………………………..

4e.Does the time of harvest contributes to losses? YES [ ] NO [ ]

4f. If YES, explain ……………………………………………………

…………………………………………………………………………

5a. Do you apply any treatment(s) prior to harvesting? YES [ ] NO [ ]

5b. If YES, explain …………………………………………………..

……………………………………………………………………….

6a. Do you experience any postharvest change(s) on the harvested mushrooms?

YES [ ] NO [ ]

6b. If YES, explain ……………………………………………………….

………………………………………………………………………

6c.Do the changes contribute to losses? YES [ ] NO [ ]

6d. If YES, state the type of changes ……………………………………….

………………………………………………………

6e.What quantities do you produce weekly? <10Kg [ ] 10-20Kg [ ]

21-30Kg [ ] 31-40Kg [ ] 41-50Kg [ ] above 60Kg [ ]

6f. In your estimation what proportion of mushrooms do you lose weekly on the farm? <1% [ ] 1-5% [ ] 6-10% [ ] 11-15% [ ] 16-20% [ ] 21-25% [ ] 26- 30% [ ] above 30% [ ].

6a. Do you use any special tool for harvesting?

……………………………………………………………………………

6b. If YES, state it …………………………………………………..

…………………………………………………………………………..

7. How do you handle the mushrooms after harvest? Sorting [ ] Wrapping in white perforated polythene bag (low density) [ ] wrapping in imperforated white polythene bag (low density) [ ] storage [ ] others [ ]

(specify)…………

8a.What management practices do you carry out during the production stage? Watering at interval [ ] spraying with chlorinated water [ ] provision of ventilation [ ] regular inspection [ ] others

(specify)……………………………………………..

8b. Do these practices encourage good yield? YES [ ] NO [ ]

8c. If NO explain …………………………………………………………

………………………………………………………………………….

9a. If you are supported financially, will you produce more mushrooms?

YES [ ] NO [ ]

9b. If YES, why? …………………………………………………………………

9c. If NO, why? ……………………………………………………………..

10a. Is mushroom farming lucrative? Yes [ ] NO [ ]

10b. If YES, why? ………………………………………………………………

10c. If NO, why? ……………………………………………………………… 11a. Do you face any problem(s) in mushroom productions?

YES [ ] NO [ ]

11b. If Yes, state them? Lack of financial support [ ] climatic problem [ ] high cost of spawn [ ] storage problem [ ] pests and diseases infestation [ ] postharvest changes [ ] high cost of mushroom house construction [ ] others [ ] (specify)…………………………

12. What factors contribute to postharvest losses in the mushroom production in this area? High moisture content [ ] poor storage technology [ ] postharvest changes [ ] pests and diseases infestation [ ] environmental conditions [ ] metabolic factors [ ] limited alternative preservation technology [ ] others [ ] (specify)……………

13. Any additional comments …………………………………………………………
…………………………………………………………………………………………

(C) STORAGE

14a. Do you store the harvested mushrooms? YES [ ] NO [ ]

14b. If YES, mention the storage methods. Drying [ ] refrigeration [ ] salting [ ] smoking [ ] others [ ]
(specify)…………………………………………………………

14c.How long do the mushrooms stay in storage? If it is:

(i) Refrigeration method …………………………………………………………

(ii) Drying method…………………………………………………………

(iii) Salting method …………………………………………………………

(iv) Smoking method…………………………………………………………

14d. Do you give any treatment(s) before storage? YES [ ] NO [ ]

14e. If YES, explain ……………………………………………………………

15a. Do the treatment(s) enhance(s) the shelf life and quality? YES [ ] NO [ ]

15b. If yes explain...

16. In your estimation what proportion is lost during postharvest handling < 1% [ ] 1- 5% [ ] 6-10% [ ] 11-15% [ ] 16-20% [ ] 21-25% [ ] 26-30% [ ] above 30% [ ]

17a. Do you package the mushrooms before storage? YES [ ] NO [ ] 17b. If YES, state the packaging material(s). Low density white perforated polythene bags [ ] low density white imperforated polythene bags [ ] papers [ ] sacks [ ] others [ ] (specify)

16c. If NO, why? ……………………………………………………………..

18. In which forms do you sell the mushrooms to marketers?

Fresh forms [ ] dried form [ ] smoked form [ ] others [ ] specify………………..

19 .Any additional comments……………………………………………………..

QUESTIONNAIRE FOR MARKETERS OF OYSTER MUSHROOM (A) SOCIAL BACKGROUND OF RESPONDENTS

1. Name……………………………………………………………………….
2. Age: 20 and below [ ] 21-30 [ ] 31-40 [ ] 41-50 [ ] 51-60 [ ] 60+ [ ]

3 Gender: Male [ ] Female [ ]

4. Educational status…………………………………………………………..

(I) Basic[ ](ii) Secondary[ ](iii) Tertiary [ ] (iv)Non-formal [ ](v)Others[ ] specify…….

5. Occupation……………………………………………………………………….

6. Religion……………………………………………………………………….

7. Hometown……………………………………………………………………….. 8. Residential Area…………………………………………………………….

9. Social Status………………………………………………………………...

(B) MARKETING

1a. Do you sell mushrooms YES [ ] NO [ ]

1b. If YES, which type(s) do you sell? Oyster mushrooms [ ] oil palm mushrooms [ ] button mushrooms [ ] others [ ]

(specify)……………………………………………

1c.Why do you sell such a type? Consumers demand [ ] its availability [ ] its seemingly long shelf life [ ] others [ ]

(specify)…………………………………………………………

1d. How many years have you been marketing mushrooms? < 1 year [ ] 1-3 years [ ] 4-6years [ ] 7-9 years [ ] 10-12years [ ] more than 12years [ ] (specify)…………………………………………….

1e. What quantities do you sell weekly? 20Kg and below [ ] 21-25Kg [ ] 26-30Kg[ ] 31-35Kg [ ] 36-40Kg [ ] 41-45Kg [ ] 46-50Kg [ ] above 50Kg [ ]

1f. In which forms do you sell the mushrooms? Fresh forms [ ] dried forms [ ] salted forms [ ] smoked form [ ] others [ ]

(specify)………………………………..

1g. Do you package the mushrooms before marketing? YES [ ] NO [ ]

1h.If YES, Which package material(s) do you use? Low density white perforated polythene bags [ ] low density imperforated white polythene bags [ ] papers [ ] sacks [ ] others [ ]

(specify)…………………………………………….

2a. Is the business lucrative? YES [ ] NO [ ]

2b. If YES, why? Consumers" demands [ ] its availability [ ] others [ ]

(specify)…..

2c. If NO, why? Type of mushroom [ ] consumers lack of interest [ ] others [ ]

(specify)…………………………………………………………………………

3.In your estimation what quantities do you lose during marketing period? < 1% [ ] 1-5% [ ] 6-10% [ ] 11-15% [ ] 16-20% [ ] 21-25% [ ] 26-30% [ ] above 30%

4a.Would you like to continue with this business? YES [ ] NO [ ]

4b. If YES, state reason(s) ………………………………………………………..

4c. If NO, state reason(s) …………………………………………………………

5a. Do you experience any postharvest changes(s) during the marketing period? YES [ ] NO [ ]

5b. If YES, state them. Brown discolouration [ ] wilting [ ] weight lose [ ] veil opening [ ] others [ ]

(specify)…………………………………………………………………………

5c. Do these contribute to losses? YES [ ] NO [ ]

6a. Do you have problems with marketing your mushrooms? YES [ ] NO [ ]

6b. If YES, identify them…………………………………………………..

Rejection of deformed mushrooms [ ] storage problems [ ] lack of organized market for the mushrooms [ ] others [ ] (specify)………………………………………………….

7a. Is there a demand for the mushrooms in this area? YES [ ] NO [ ] 7b. If YES, why? Awareness of nutritional value [ ] Awareness of medicinal value [ ] its delicacy [ ] others [ ] (specify)

7c. If No why? ……………………………………………………………………..

(C) STORAGE

8a. Do you store your mushrooms during the marketing period? YES [ ] NO [ ]
8b. If YES, Which storage method(s) do you use? Refrigeration method [ ] drying method [ ] salting method [ ] smoking method [ ] others [ ]

specify…………………………

8c. How long do the mushrooms stay in storage? If it is:

(i) Refrigeration method……………………………………………………………..

(ii) Drying method………………………………………………………………….

(iii) Salting method…………………………………………………………………

(iv) Smoking method ………………………………………………………………

9a.Do you package the mushrooms before storage? YES [ ] NO [ ]

9b. If YES, what package material(s) do you use? Perforated low density white polythene bag [ ] Imperforated low density white polythene bag [ ] papers [ ] others [ ] specify…………………………………………………. 10. In your estimation how much do you lose during storage period? < 1% [ ]

1-5% [ ] 6-10% [ ] 11-15% [ ] 16-20% [ ] 21-25% [ ] 26-30% [ ] above 30%

11. What factors contribute to losses of the mushrooms during marketing periods? Exposure to heat [ ] lack of organized market [ ] lack of processing facilities [ ] inadequate storage facilities [ ] others [ ]

(specify)……………………………………….

12. Any additional comments…………………………………………………….

QUESTIONNAIRE FOR CONSUMERS OF MUSHROOMS (A) SOCIAL BACKGROUND OF REPONDENTS

1. Name……………………………………………………………………
2. Age. : 20 and below [ ] 21-30 [ ] 31-40 [ ] 41-50 [ ] 51-60 [ ] 60+ [ ]

3. Gender: Male [ ] Female [ ]

4. Educational status……………………………………………………………..

(i) Basic [ ] (ii) Secondary [ ] (iii) tertiary [ ] (iv) Non-formal [ ]

(v) Others [ ]

(specify)…………………………………………………………………………

5. Occupation……………………………………………………………………….

6. Religion………………………………………………………………………….

7. Hometown………………………………………………………………………..

8a. Residential Area……………………………………………………………….

8b. Number in the household. 1-3 [ ] 4-6 [ ] 7-9 [ ] 10+ [ ]

9. Social Status…………………………………………………………………….

(B) CONSUMPTION

1a. Do you consume mushrooms YES [ ] NO [ ]

1b.Which type(s) do you consume? Oyster mushroom [ ] oil palm mushroom [ ] button mushroom [ ] others [ ]

(specify)……………………………………………….

1c.Why do you consume such a type? Tasty delicacy [ ] nutritional value [ ] medicinal value [ ] its availability [ ] others [ ]

(specify)………………………………………….

1d.Can you mention any nutritional content of the mushroom consumed?

YES [ ] NO [ ]

1e. If YES, identify them; protein [ ] minerals [ ] vitamins [ ] carbohydrate [ ] fats [ ] others [ ] (specify) ……………………………………………… 1f.Can you mention any medicinal value derived from mushroom consumptions? YES [ ] NO [ ]

1g. If YES, state them; prevention of diabetes [ ] prevention of hypertension [ ] reduce fatness (weight-watchers) [ ] others [ ]

(specify) ……………………………………

2a. Do you buy mushrooms? YES [ ] NO [ ]

2b.How much do you purchase for consumption per week? < 5Kg [ ] 5-6Kg [ ] 7-8Kg [ ] 10+Kg [ ]

2c. What quantities of mushrooms do you consume (per household)?

< 1kg per week [ ] 1-2kg per week [ ] 3-4kg per week [ ] 5-6kg per week [ ] 7-9kg per week [ ] more than 9kg per week [ ]

3. What factors contribute to these losses? Browning discolouration [ ] lack of preservation technological knowledge [ ] limited alternative uses of mushrooms [ ] others [ ] (specify)…………………………

4. In which form do you get the mushroom for consumption? Fresh form [ ] dried form [ ] salted form [ ] smoked form [ ] others [ ] (specify)………………………

5. Which part of the year do you have access to mushrooms for consumption?

All year round [ ] rainy season [ ] dry season [ ]

(C) STORAGE

6a. Do you store the mushrooms for consumption? YES [ ] NO [ ]

6b. If YES, which methods of storage do you practice? Drying [ ] refrigeration [ ] smoking [ ] salting [ ] others [ ] (specify)………………………………………..

6c.How long do the mushrooms stay in storage? If it is:

(i)Refrigeration method………………………………………………………..

(ii)Drying method……………………………………………………………

(iii)Salting method………………………………………………………….

(iv)Smoking method…………………………………………………………

6d. Which packaging material do you use for storage? Low density white perforated polythene bag [ ] Low density white imperforated polythene bag [ ] paper [ ] sacks [ ] others [ ]

(specify)…………………………………………………………………

6e. Do you apply any treatment to the mushrooms before storage? YES [ ] NO [ ]

6f. If YES, state the treatment method and explain……………………………….

7. How much do you lose during storage period per household? 1% < [ ] 1-5%[] 6-10% [ ] 11-15% [ ] 16-20% [ ] 21-25% [ ] 26-30% [ ] above 30% [ ]

8. What factors contribute to postharvest losses of oyster mushrooms during storage period? Texture changes [ ] browning discolouration [ ] dehydration [ ] fluctuation of electricity [ ] others [ ]

   (specify)…………………………………………………………………………

9. Any additional comments……………………………………………………………

APPENDIX 3

Pictures of some activities of mushroom production in the Ho Municipality

Bagging with sawdust

Spawning stage

Spawning stage

Mushroom bags being arranged on shelves

Watering stage **Flushing stage**

Harvesting stage **Harvested oyster mushrooms**

Mushroom stew and soup displayed

Mushroom stored in refrigerator

Mushrooms stored at room temperature

A sample of oyster mushroom in polythene bag being weighed.

A sample of oyster mushroom in perforated bowl being weighed.

APPENDIX 4 Colour wheel and chart to determine mushroom discolouration after harvest

value and intensity.
; on the right side of
heel arranged accord-
ations on a gray value

s—red and green—in a
f values from high
dark.
red at normal value
, from ¼ intensity to
ty.