CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Mushroom is defined as a macrofungus with a distinctive fruiting body which can either be found growing on the ground or underground. The macrofungi have fruiting bodies large enough to be seen with the naked eye and can be picked up by hand (Mushworld, 2004). It requires an organic substrate (medium) which is rich in nutrients, particularly Nitrogen, Phosphorous and Potassium (Aboud et al., 2005; Rogers & Davis, 1972). The material has also to be rich in lignin and cellulose, which form nutrition to mushroom mycelium (Kimenju et al., 2009).

Mushrooms were initially classified as vegetables for many years. During the second half of the 20th century, they were grouped into a separate kingdom known as fungi kingdom, since they are neither true vegetables nor animals (George &Pamplona, 2004).The species of fungi globally are estimated at 1.5 million, and only 64,000 species have been described so far (Oei, 2003). Many species from tropical rain forests and remote areas may have disappeared before science had an opportunity to describe them. About 10,000 species produce the fruiting bodies which are called mushrooms, approximately 300 types of edible mushrooms and about 30 types have been domesticated and cultivated (Chang & Miles, 1997).

Environmental growing conditions for mushrooms have to be observed and managed well. The critical conditions which can adversely affect mushroom production include temperature and relative humidity in all phases of growth such as spawn running, fruit induction and harvesting (Kivaisi ,2007),

The Millennium Development Goals (MDGs) focus on poverty reduction as one of the major priority areas. This is aimed at reducing the proportion of people living in extreme poverty by half by 2015 (Okemo, 2001). The expansion of mushroom industry could contribute to MDGs which is a global concern. Odendo et al. (2014) has indicated that mushroom is a high value niche product with great potential to contribute to enterprise diversification and poverty alleviation.

Quimio (2002) found that oyster mushrooms are suited throughout the third world in areas that are rich in plant wastes such as sawdust, sugarcane bagasse and others which can be used as substrates. A study by Gibriel et al. (1996) indicated that oyster mushroom has a high colonizing ability and can grow on virtually any agricultural waste unlike other mushrooms. This explains why the oyster mushroom is often preferred for cultivation by majority of mushroom growers especially the starters.

Mushroom production is completely different from growing of green plants. Since they do not contain chlorophyll, they depend on other plant materials for their food (Alice& Michael, 2004). Poppe (2000) conducted a worldwide survey focusing on suitable substrates for mushroom cultivation and recorded 200 kinds of wastes that have been proven to be useful for oyster mushroom growing. These come mainly from agricultural and forestry (Agro-Forestry) residues, available for small or large scale cultivation of oyster mushrooms .The extent of utilization of these materials depend on their availability in abundance and suitability. The commonly used substrates from agricultural wastes include all the cereal straws, corncobs, sugarcane bagasse, coffee residues, and banana fronds (Dietzler, 1997). However, bagasse is considered the best substrate (Wachira, 2003; Kimenju et al., 2009).

Fermont *et al*. (2008) indicates that the agricultural waste as a major source of substrate for mushroom production has limitation concerning its availability in Kenya just like any other country. This is because the Kenyan population is on a continuous increase against a declining acreage of arable land. Consequently, the available arable land is being subdivided into smaller parcels which are intensively cultivated. The ultimate result has been a decline in agricultural productivity and sustainability of agro-ecosystems (Statistical Abstract, 1999). In addition to decline in productivity, availability is dependent on seasons (Kivaisi, 2007). Most of agricultural activities take place during rainy seasons, thereby limiting agro-wastes availability throughout the year.

Wachira (2003) and Kimenju et al. (2009) have indicated that bagasse has been identified as the best substrate for mushroom production and is considered as the standard substrate. However, its availability is diminishing fast from the sugar industry. Currently the major alternative use of bagasse is the production of electricity.

Sawdust is a by- product of lumbering or wood industry. Poppe (2000) has enlisted sawdust among the 200 types proven as good substrates for mushroom production despite some limitations. The study by Spelter (2008) showed that sawdust has been put into many uses because of innovations such as bedding for animals and biomass for power plants.

According to Chang (1999) the world production of edible and medicinal mushrooms has been on an upward trend. In 1965, about 350,000 metric tons were produced and by 1997 there was 6,160,800 metric tons. This shows that in a period of 32 years, the production increase was 181,587.5 (51.9%) metric tons annually. Beharilal (2014) has also shown that the expansion witnessed is both horizontal and vertical, meaning an increase in mushroom production and additions of newer types of mushrooms for commercial production comprising of edible and non-edible mushrooms. Chang (1999) indicates that in oyster mushroom production globally, China is the leading and Africa is the least.

In Africa (FAO, 2002), mushroom production for either the local or external markets is in most countries at its infancy stage. It is only South Africa, Zimbabwe and Kenya that have been reported to produce mushroom on a commercial scale.

In East Africa, production of mushroom is on the increase although the expansion rate is slow. According to Kivaisi (2007), mushroom production was first introduced to Tanzania in 1993. The focus was on cultivation of oyster mushrooms a common type of mushroom in Tanzania. The production has been estimated at 960 tons of fresh mushroom annually.

According to Wambua (2004), Kenya has a potential of producing over 100,000 tons of mushroom every year. However, current mushroom production is estimated at 500 tons per annum which is far below the potential while the consumption is estimated at 650 tons. This creates a shortage of 150 tons. The shortage is often met by importing from countries whose production is high like China (Dinghaun & Xiaoyong, 1978). Njagi (2009), has reported that Kenya imports mushrooms worth Kshs10 million annually from

China. A probable reason for the low production of mushroom which is not marching the demand could be attributed to inadequate availability of substrate. Sigot (2010) has cited another reason as lack of communication between the researchers in this field and the mushroom growers.

Bertil and Gunilla (2000) initiated Rivendell Mushroom Project at Rivendell Gardens in Shinyalu Division of Kakamega Sub-County (Formerly Kakamega District). The aim was to assist poor farmers to create extra income, extra food and create employment. Unfortunately, the project collapsed immediately the initiators left the country to Sweden. However, the idea was later adopted at Vihiga sub-County formerly Vihiga district by a community based organization known as Vihiga Mushroom Project (Vimpro).

Family Concern (2005) indicated that bagasse as a substrate for mushroom production was supplied to the project by Mumias Sugar Factory. The economic activities of the growers in the project were hindered by the unexpected problem of suspension of sugarcane bagasse supply from the factory. Mumias Sugar Factory stopped supplying sugarcane bagasse in 2009.Sugarcane bagasse had been previously dumped by the factory, so the project could get the substrate material for free. However, the factory stopped disposing of the bagasse after it found that the waste could be utilized by the cogeneration plant. This caused a serious problem for the project leading to depressed production. The mushroom production in 2009 was 73370kg (fresh) and 56kg (dry) which dropped to 1782kg (fresh) by 2011, reduction of 97.4% and increased to 95kg dry while there was no production in 2012 as shown in Appendix VI.

The sawdust is a by- product of lumbering or wood industry. Poppe (2000) has enlisted sawdust among the 200 types proven as a good substrate for mushroom production despite some limitations. The study by Spelter (2008) showed that sawdust has been put into many uses because of innovations such as bedding for the animals and biomass for power plants. Shortages have also been caused by the closure of sawmills (Vancourver, 2008; Spelter, 2008). Tom (2003) has indicated that deforestation is one of the causes of sawdust shortage. Hyung & Brung (2004), indicated that not all tree species can produce suitable sawdust for mushroom production. Therefore, relying on sawdust alone as a substrate for mushroom production may lead to depressed production. Despite the many uses to which sawdust has been put, the existence of wood industry gives an assurance of sawdust being available even if in small quantities. The small quantities being generated cumulatively could result into large volumes. This, to some extent, can sustain the mushroom industry. Kenya Agricultural and Livestock Research Organization (KALRO) formerly referred to as KARI, evaluated performance of oyster mushroom on sawdust substrate (KARI, 2011) and found that it was suitable for mushroom production.

In an attempt to promote mushroom production in Vihiga County through Vihiga Mushroom Project which will also be replicated in other mushroom growing areas, there was need therefore to identify an alternative material for partial or complete replacement of bagasse. Water hyacinth (*Echhornia crassipes)* can be a possible potential substrate for oyster mushroom production. This prolific aquatic weed is locally available in abundance from Lake Victoria (Obiero et al., 2001).

Navarro and Phiri (2000) describe water hyacinth (*Eichhornia crassipes*) as a flowering, thick floating mat, and freshwater plant. It has beautiful, large, pale-blue flowers with purple and yellow spots on the petals and shiny round green leaves. It originated in Latin America, and is believed to have been introduced to Africa in the 19^{th} century by Belgian colonists who wanted to adorn ponds with it (Tom, 2003). Currently, water hyacinth has proliferated across the lakes and rivers of Central and Eastern Africa.

The weed is known as the world's fastest growing water-borne weed with ability to double its biomass in less than two weeks (Lewis, 2002). A single plant can produce 3000 others in 50 days and cover an area of $600m^2$ of water surface in a year (James, 2002). Oketch (2013) has indicated that the plant occupies an area of 68000ha, equivalent to $680km^2$ in Lake Victoria. The plant can yield 322.2 tons of biomass from one hectare per year (Aboud et al., 2005).In their study, Obiero et al. (2001) revealed that 10 million metric tons of dry biomass per year can be obtained from Lake Victoria which can support mushroom industry.

The importance of water hyacinth stems from its potential to produce negative consequences for the productive and habitat quality of water bodies and for the communities that depend on them. The adverse impact of the excessive growth of water hyacinth is being felt in the economics of Zimbabwe, Malawi, Zambia, Tanzania, Kenya and Uganda (Gitonga, 2011; Phiri, 1997). Three basic techniques exist for its control namely mechanical, biological and chemical. In his article, Athembo (2011) refers to these techniques as, 'Repetition of failed past efforts to control the hyacinth'. Athembo (2011) further argues that water hyacinth deserve to be treated as an important natural resource for economic development rather than destroying it.

McGrath (2003) has singled out the work of Tagwira who established demonstration farms in Zimbabwe for oyster mushrooms using water hyacinth substrate. The farms yielded 40 to 50kgs of fresh mushroom per day, worth about USD 55-70 in the local market. This study has not mentioned other substrates which were being used in Zimbabwe in producing oyster mushroom or compared the obtained result with any other in order to conclude that water hyacinth is a good substrate for oyster mushroom.

Kivaisi et al. (2004) conducted a study on the performance of *Pleurotus flabellatus* using water hyacinth shoots at two different temperature and relative humidity in Tanzania. The objective was to determine the suitability of the weed for growing the domesticated strain (*Pleurotus flabellatus*), at two places with different temperature and relative humidity regimes (18-25^{o}C/27-29^{o}C and 55-85/79-93%), at Dar es Salaam and Moshi. The result showed that there was better performance of mushrooms at high environmental conditions at DSM than at lower temperature and relative humidity at Moshi. The study concluded that water hyacinth shoots proved to be a good substrate for growing the local oyster mushrooms at ambient environmental conditions.

In their study based on suitability of locally available substrates for oyster mushroom cultivation in Kenya, Kimenju et al.(2009) selected ten substrates, among them water hyacinth (*Eichhornia crassipes)* and sawdust (*Eucalyptus sp*) for evaluation. The objective was to determine the suitability of locally available substrates for oyster mushroom production. The results obtained showed that the organic substrates were significantly different in suitability for oyster mushroom production. It was concluded that many organic substrates have high potential for utilization as substrates.

A study by Gibriel et al. (1996) on cultivation of oyster mushroom evaluated three substrates: Sawdust, Rice straw and Water hyacinth. The result showed that the highest yield of fresh mushroom was obtained from Rice straw (2448gm) ,sawdust was the second best organic substance tested, while water hyacinth was the third. In this study, no data was given on both sawdust and water hyacinth. It also lacked data on production cycles (flushes) and information on whether the entire plant of water hyacinth was used or just a portion of it.

From the literature reviewed, it is clear that all the authors had an interest in oyster mushroom production and made an effort to investigate the possible use of water hyacinth as a substrate to promote mushroom production. It is observed that Kivaisi et al. (2004) used water hyacinth shoots to evaluate the performance of *Pleurotus flabellatus* but not oyster mushroom. Kimenju et al. (2009) and Gibriel et al. (1996) evaluated the use of locally available substrates which included water hyacinth for oyster mushroom production. None of the authors clarified whether entire plant was used or just a portion of it. McGrath, 2003 reported that oyster mushroom can be grown using water hyacinth but has provided little information. The author did not include the number of flushes obtained, standard substrate used and never mentioned the portion of water hyacinth which was used.

The above studies have explored the use of water hyacinth for mushroom production. This aquatic plant is available in abundance from Lake Victoria and is expected to remain here for a long time due to its characteristics. Bagasse is considered as the best substrate, however, its availability is diminishing fast from Sugar millers due to recent innovations resulting in many alternative uses for it.None of the above authors has attempted to use water hyacinth as a possible replacement to bagasse. Therefore, no study has focused on the use of water hyacinth as a replacement for oyster mushroom production.

In their study based on evaluation of water hyacinth and paddy straw waste for culture of oyster mushroom in India, Nageswaran et al. (2003) used water hyacinth as a supplement. The plant was evaluated at 25%, 50 % and 75% levels with Paddy straw. The result showed that harvesting of mushroom from water hyacinth and paddy straw at a ratio of 1:1, took 14 days to harvest first flush and attained 7 flushes during production cycle with a biological efficiency of 73%.They concluded that mixing water hyacinth and paddy straw at a ratio of 1:1 was suitable substrates for early harvests to other substrates.

Bandopadhyay (2013) evaluated the effect of supplementing rice straw with water hyacinth on the yield and nutritional qualities of oyster mushroom. The study focused on three mushroom species: *Pleurotus florida*, *P.citropileatus* and *P.pulmonarious.* The objective of the study was to determine the effect of the weed on the biological yield as well as on nutritional qualities of the mushrooms. The yield obtained from rice straw mixed with water hyacinth at a ratio of 1:1 was high compared to when the substrates were used alone. The study concluded that there were no significant differences due to supplementation of rice straw with water hyacinth.

Naresh et al. (2013) studied the production of white button mushrooms using water hyacinth as a substrate in various seasons (Summer, rainy and winter). The aim was to test aquatic plant as a substitute to paddy straw (Rice) for the cultivation of Agaricus bisporus mushrooms and two flushes were considered. The maximum yield was obtained from rainy season (0.87kg) and minimum was from summer (0.76kg). The results proved

\that water hyacinth was a viable substrate for white button mushroom cultivation. It was concluded that water hyacinth is a good substrate for the production of white button mushroom.

Kholoud et al. (2014) used date palm leaves with other agro wastes which included wheat straw (WS), sawdust (SD) and Boobialla leaves (BL) to grow oyster mushroom in the Kingdom of Saudi Arabia (KSA).The objective of the research was to study the efficiency of cultivating oyster mushroom on date palm wastes (leaves) mixed with other agricultural wastes available in KSA. The materials sawdust, Boobialla leaves and wheat straw were mixed with date palm leaves at different ratios. Date palm leaves was mixed with wheat straw at the ratio of 25% and 75% respectively. The yields obtained from this combination was the best compared to the other mixes. The mixture also gave the best results for other parameters which were investigated.

Shah et al. (2004) did a comparative study on cultivation and yield performance of oyster mushroom in Pakistan. The objective was to investigate the cultivation of oyster mushroom on different substrates (sawdust, wheat straw and leaves). The mixing ratios were: sawdust and wheat straw (50%:50%), sawdust alone (100%), sawdust and leaves (75%:25%), wheat straw alone (100%),wheat straw and leaves (50%:50%) and finally leaves alone (100%).The maximum yield of 648.5g was obtained from sawdust, therefore it was recommended for oyster mushroom production.

According to the literature reviewed above, different authors have focused on production of mushrooms using mixed substrates. Their findings indicate that when substrates are mixed, they enhance mushroom production. The studies by Nageswaran et al. (2003) and

Bandopadhyay (2013) looked at the use of water hyacinth as a supplement to rice straw at a ratio of 50%:50% and 1:1 respectively for the production of oyster mushroom. In their study, water hyacinth is considered as a supplement to rice without explaining the rationale. The mixing ratio for the substrates is the same, therefore it is not clear why water hyacinth is considered as a supplement. Other authors focused on different substrates which have been mixed at varied ratios to grow mushrooms. Neresh Reddy et al.(2013) reported the possible use of water hyacinth as a substitute to paddy straw for white button mushroom production while Kholoud et al.(2014) dwelt on the use of date palm leaves mixed with other agro wastes (WS, SD and BL) at ratio of 25%:&75%, for oyster mushroom production. The study by Shah et al. (2004) compared varied ratios (25%, 75%, and 100%) of sawdust, wheat straw and leaves as substrates for oyster mushroom production. This study has not indicated the type of plant which produced the leaves used in the experiment.

From the works of these authors, it is evident that all of them were interested in using mixed substrates for mushroom production. They explored water hyacinth mixed with paddy straw, date palm leaves mixed with sawdust and wheat straw mixed with sawdust. No study has attempted to use water hyacinth mixed with sawdust as a substitute to bagasse for the production of oyster mushroom. Consequently oyster mushroom production using this mixture is unknown

Mushroom production is an economic activity whose returns have been very impressive in some countries. Prophant (2005) analyzed the cost and benefit of Coprinus mushroom using rice straw substrate in Thailand and found that the net profit was high. The production period for this mushroom is quite short and lasts only an average of one month. Mushroom growers can grow 10-12 crops per year and produce huge income.

In Philippines, bed production of the button mushroom using rice straw substrate was done as a project by the University of the Philippines (Quimio, 2002). The contractual approach was tried in a small farming community on family-based groups. Each family had to prepare 20-40 beds per month and produce at least 95 kg fresh buttons per growing cycle of 23 days. Marketing of mushroom was done by the University of the Philippines which sponsored the project. After harvesting the mushrooms, profitability was analyzed and showed that growers made good money from mushroom business.

A study conducted by Ram et al. (2010) on benefit-cost analysis and marketing of mushroom in Haryana, India, focused on three categories of farms: Small (up to 120), medium(120-240) and large (above 240) farmers. The results revealed that as the farm size increased, income generation capacity of the mushroom growers also went up. As a result, the large mushroom growers earned more profit than small and medium growers. The average gross returns ranged between Rs88202 and 735100, while the benefit cost ratio (BCR) was 1.61 (small farm), 1.78 (medium) and 1.83 (large).The substrate used by farmers was wheat straw on production of button mushroom.

Kivaisi (2007) on mushroom production from Mbeya District in Tanzania where bean trash was used as a substrate for oyster mushroom production showed that growers were making good money from the mushroom business. The mushroom producers/growers having been motivated by profits thus have formed an association known as Tanzania

Mushroom Growers Association (TMGA), aimed at creating more wealth and taking advantage of economies of scale in their operations.

From the literature reviewed, it was observed that Ram et al. (2010) analyzed profit of button mushroom grown on wheat straw by comparing three farms in India. The benefit cost ratios (BCR) were: 1.61(small farm), 1.78(medium) and 1.83(large).Ram and the co-workers concluded that growers from large farms made more profits. They have considered one benefit only namely the yield of button mushroom leaving other benefits which can be monetized. Other authors who analyzed profits from different mushrooms using different substrates did not focus on BCRs which is a critical component in determining profit margins.Kivaisi (2007) looked at profit margins of oyster mushroom using bean trash in Tanzania but considered payback period(PBP). Prophant (2005) dwelt on profits from coprinus mushroom using rice straw while Quimio (2002) reported profits from button mushroom using rice straw.

The above studies, indicate that profits from mushroom production is emphasized regardless of the type and substrate used. It is also evident that all the authors have considered yield only as a benefit in their analysis, leaving other benefits which can be monetized. Despite these results associated with profits from mushrooms, none of the study has focused on economic profit of oyster mushroom using water hyacinth alone and when water hyacinth is mixed with sawdust. Consequently, economic profit of oyster mushroom grown on water hyacinth and when it is mixed with sawdust is unknown.

1.2 Statement of the problem

The Vihiga Mushroom Project (Vimpro) is faced with imminent collapse due to suspension of bagasse substrate material supply from Mumias Sugar Factory that threatens the livelihood of mushroom growers on this project. The project has used bagasse for mushroom production since its inception in 2002.In the past the sugarcane bagasse was abundantly available and was being dumped, so the project could get the substrate material for free. However, the factory stopped disposing of the bagasse in 2009 after it found that the waste could be utilized by the cogeneration plant to generate electricity for sale to the national grid. The shortage caused a serious problem to the project leading to declined production from 73370kg fresh mushrooms in 2009 to 1782kg by 2011 and none in 2012. Studies have shown that agricultural and forestry wastes could be used as substrates but their availability in abundance is affected by land scarcity and seasonality. In an attempt to promote mushroom production in Vihiga County through Vimpro, there has been a need to identify an alternative substrate for replacement to bagasse. A possible potential substrate can be water hyacinth which is locally available in abundance from Lake Victoria. Various studies have shown that the plant is suitable for mushroom production. However, no study has focused on the use of hyacinth as a replacement to bagasse. Moreover, no study has been conducted on the use of water hyacinth mixed with sawdust for production of oyster mushroom. The economic profits of oyster mushroom grown on water hyacinth alone and when it is mixed with sawdust are also unknown. Therefore this research sought to evaluate water hyacinth alone and when mixed with sawdust as alternative substrates to bagasse for oyster mushroom production in Vihiga County, Kenya.

1.3 Objectives of the study

The general objective was to conduct economic evaluation of water hyacinth and sawdust as alternative substrates for oyster mushroom production in Vihiga County. Specifically, the study sought to;

i. Evaluate the possible use of water hyacinth as a replacement to bagasse for production of oyster mushroom in Vihiga County

ii. Evaluate the possible use of water hyacinth mixed with sawdust as a substitute to bagasse for production of oyster mushroom in Vihiga County

iii.Determine the effect of water hyacinth alone and when mixed with sawdust on economic profit of oyster mushroom production in Vihiga County.

1.4 Hypotheses of the Study

This study was guided by the following hypotheses;

***H_oi*:** There is no significant difference between water hyacinth alone and bagasse on production of oyster mushroom

$H_o$ii: There is no significant difference between water hyacinth mixed with sawdust and bagasse on production of oyster mushroom

***$H_o$iii*:** There is no significant difference in using water hyacinth alone and when mixed with sawdust on economic profit of oyster mushroom.

1.5 Scope of the study

The study was conducted in Vihiga County where Vihiga Mushroom Project (Vimpro) is located (Appendix XI). The source of water hyacinth was Lake Victoria, sawdust was from wood industry which is found within Vihiga and the source of bagasse was Kibos Sugar Company Limited. The study concentrated on general information of the mushroom production, water hyacinth, water hyacinth mixed with sawdust and economic profit from mushrooms. The study period was 2009-2013.

1.6 Significance of the study

The study makes significant contributions on various fronts. Mushroom business offers many opportunities such as wealth creation, poverty reduction and job creation. These opportunities could be lost if the mushroom industry collapse. Vihiga Mushroom Project is faced with imminent collapse due to shortage of sugarcane bagasse and therefore threatening the livelihood of those who depend on it. The project reported drastic reduction in mushroom production after the diversion of sugarcane bagasse used as substrate into electricity generation when the cogeneration plant was established and used it as a raw material. Therefore, the study findings could be beneficial to Vihiga Mushroom project for the improvement of mushroom production and, by extension, to the rest of mushroom growers in the country.

The study's attempt at seeking greater insights on utilization of water hyacinth and sawdust could assist in policy formulation aimed at the economic growth and development of programmes by County and National Governments. Currently, programmes are being developed aimed at combating water hyacinth from lakes and rivers especially in Lake Victoria. Therefore the findings of the study could be beneficial to policy makers.

Researchers may benefit from the result of this research especially on environmental conservation issues. The water hyacinth has posed a lot of challenges to researchers in the world particularly those from International Development Research Centre (Eglal & Dina, 2000). The findings may form the basis for further investigations which will lead to sustainable long-term solutions, which is environmentally friendly, economically empowering and socially acceptable.

Several studies have attempted to investigate the use of water hyacinth as substrate for mushroom production (Kivaisi et al.,2004; Nageswaran et al.,2003; Kimenjui et al.,2009).The researcher could not find any study on water hyacinth and sawdust as substrate in Kenya.Therefore the study makes an original and important contribution to the literature and extends existing knowledge. It also opens an venue for further research that may seek to validate the study further.

The study is further useful to the fishing industry. Fishing activities have been disrupted by the mat formed by water hyacinth in lakes and rivers, hence reducing fishing activities greatly and increasing costs. The fishers have reported losses in fishing activities such as frequent breakdown of their boats and damaged nets.

Mushroom growers in Kenya shall benefit from the study. Additional substrate could be available to mushroom producers, therefore rapid expansion of mushroom production is expected in western Kenya region and other parts of Kenya. In general, local economic activities will be stimulated and opportunity for employment created.

1.7 Conceptual Framework

Figure1.1 presents the conceptual framework adopted for this study. It provides the conceptualized interrelationships of water hyacinth, water hyacinth mixed with sawdust and bagasse (independent variables) that are expected to have an influence on production of oyster mushroom (dependent variable).This study adopted the approach by Nageswaran et al. (2003), Kimenju et al.(2009) and Prophant (2005) of using days until first harvest (Spawn run), yield per flush, biological efficiency and profits to measure production of oyster mushroom.

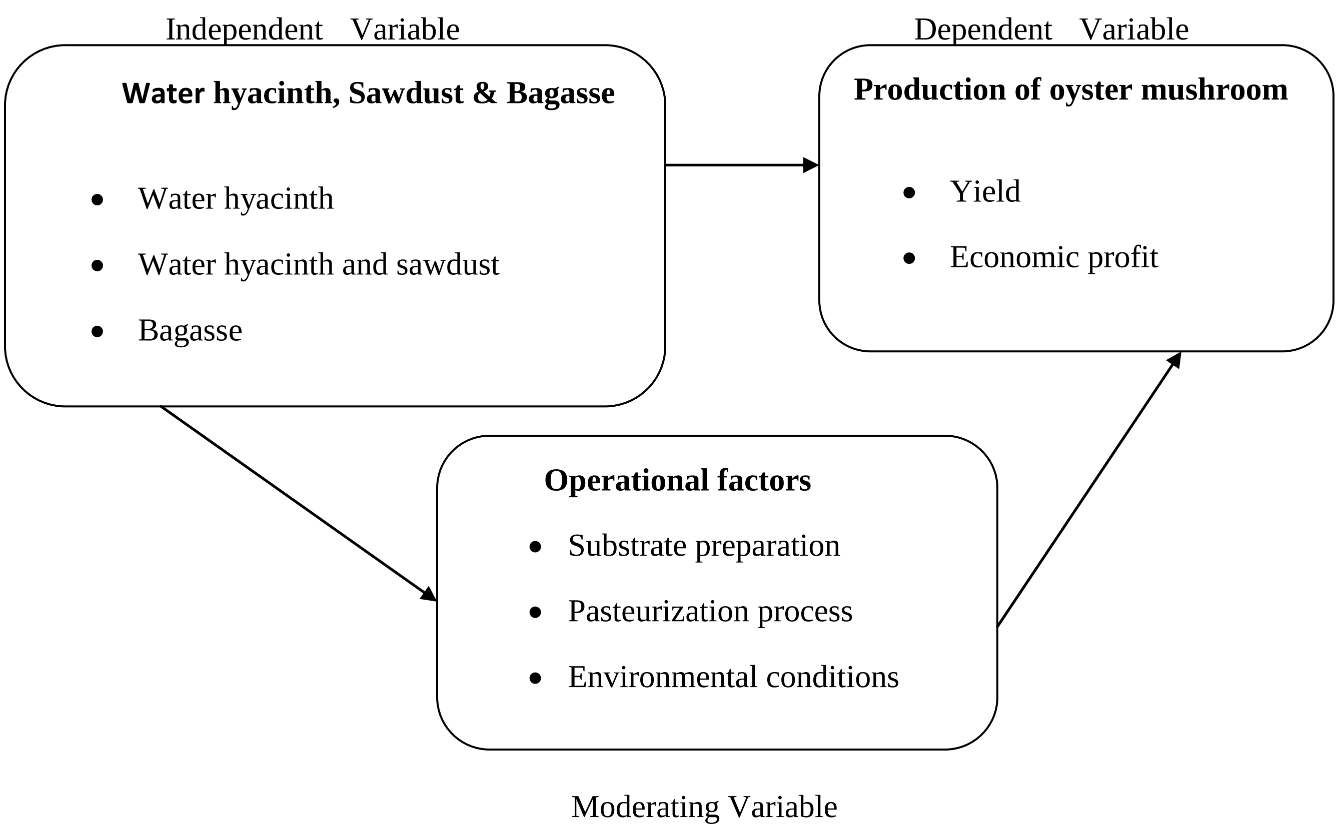


Figure 1.1: Interrelationships of water hyacinth, sawdust, bagasse and production of oyster mushroom.

Source: Self conceptualization (20120

Description of the variables

Water hyacinth, sawdust and bagasse variables

These are independent variables considered as media/substrates for mushroom production

Sawdust and water hyacinth

Sawdust is a waste from wood industry and water hyacinth is a plant growing in water bodies often considered as a menace with no economic value

Bagasse

Waste from sugarcane, used as a control substrate

Mushroom production variables

This is a dependent variable. It depends on the substrate (medium) for growth. If the medium is not available, it will cease to exist. Its performance is largely influenced by the quantity and quality of the substrate available.

Yield

The yield is the output from mushroom which can be measured in mass form and unit of measurement is in tons, kilograms and grams.

Economic profit

Evaluation of benefits and costs (BCA). All the benefits and costs incurred in undertaking mushroom production using water hyacinth are computed and compared. The difference between the two will indicate whether the planned action is advisable.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The chapter reviews theoretical literature and empirical studies. It focuses on water hyacinth, mushrooms, substrate and economic evaluation of mushroom production. It also explores comparative empirical studies to explain the gaps which the study sought to address.

2.2 Theories of the study

The review of the theories forms the foundation which guided the study. The concepts of water hyacinth and sawdust substrate on production of mushroom are anchored in the theories of discovery often referred to as Individual-opportunity Nexus Theory and Creation Theory of Entrepreneurship. These theories are complementary in nature. They have three assumptions each of which at times appear contradictory but largely complementary in nature. These two theories are applied in the analysis of three entrepreneurial phenomena: entrepreneurial decision making, the business planning process and the decision to finance entrepreneurial ventures/businesses (Alvarez & Barney, 2005). Cassim (2005) has described theses theories as developed framework within which the empirical research on small business can be synthesized. Therefore, the theoretical framework for the current study is based on the discovery theory and creation theory of entrepreneurship. The two theories have been discussed in detail in subsequent sections.

2.2.1 The Discovery Theory: Individual-Opportunity Nexus Theory

The Discovery Theory, also called Individual-Opportunity Nexus Theory (Shane & Eckhardt, 2003), finds its intellectual roots in Kirzner (1973), and has recently been reviewed and summarized by Shane (Shane, 2003). The theory has been widely studied and applied, spurring an impressive amount of research in the field of entrepreneurship and assisting to recognize the existence of business and marketing opportunities (Shane & Venkataraman, 2000).

The Theory assumes that opportunities are objective (objective opportunity), that entrepreneurs differ from non-entrepreneurs in important ways, and that the decision making context within which entrepreneurs operate is risky (Alvarez &Barney, 2005).

Discovery opportunities (Objective opportunity)

This is a central assumption of Discovery Theory that opportunities continue to exist as objective phenomena, waiting to be discovered by unusually alert people. These people are called entrepreneurs, who decide to exploit an opportunity for profit (Gaglio & Katz, 2001; Kirzner, 1973). The central task for an entrepreneur is to discover and then exploit an opportunity as a business venture. An opportunity exists when it is possible, for at least some people for some period of time to engage in activities that create the possibility of generating economic wealth (Helfat & Barney, 2004).The opportunities are objective phenomena since they have an existence independent of those who may or may not be aware of them and independent of those who may or may not be seeking to exploit them. Studies on industry and market structure will help expose the existence of the opportunities for exploitation. The entrepreneurs need to develop implementation plan quickly since this objective opportunity might be identified by another entrepreneur. This is aimed at exploiting the primary opportunity within industry or market structure in order to generate profit (Porter, 1980; Barney, 2002). The availability of the water hyacinth in abundance in Lake Victoria provides an opportunity that can be exploited quickly to create economic wealth. Due to the waves, it can cover large areas at times and also disappear from the lake occasionally.

Discovery Entrepreneurs (Unique individuals)

The variation in people's abilities to perceive opportunities is also a central assumption in the Discovery Theory. Since opportunities are objective, in principle, they should be observable by everyone in an economy. If everyone in an economy could observe an opportunity, then all could try to exploit it, thus such opportunities would never be a source of real economic wealth to anyone (Barney, 1991). All people cannot perceive opportunities equally, some will be predisposed to see them due to interest, whereas others will be blind to them because they do not care or lack training to recognize opportunities.

In order to explain why some people exploit objective opportunities while others do not, the discovery perspective must assume that people differ in their abilities to either see opportunities or once they are seen, to exploit these opportunities. This leads to the difference between entrepreneur and non-entrepreneur in opportunity exploitation. The difference is rooted on the level of alertness (Shane&Venkataram, 2000;Kirzner,1973), seen between them which is linked to differential ability of individuals to recognize information about opportunities and undertake to exploit them.This is what makes Vihiga

Mushroom Project(Vimpro) growers unique from the rest of the people of Vihiga County.

Discovery Decision making Context.

The risk bearing is also a central assumption in the Discovery Theory. The context within which entrepreneurs decide whether or not to exploit an objective opportunity will often be risky in character. A decision-making situation is defined as risky when both the possible future outcomes of a decision and probability of each of these outcomes are known at the time a decision is made (Gifford, 2003; Triola, 2003).

In these settings, unusually alert entrepreneurs can collect information about objective opportunities to gain information about the outcomes associated with exploiting an opportunity, and the probability of these different outcomes. This information is useful for calculating the present value of exploiting opportunities and make rational profit maximizing decisions about which opportunities to exploit. The Discovery Theory suggests that entrepreneurs will often make decisions about exploiting an opportunity with less than perfect information.

2.2.2 The Creation Theory

The Creation Theory finds its intellectual roots in Schumpeter (1934) and has been extended by a variety of authors (Gartner, 1985; Loasby, 2002). The Creation Theory assumes that opportunities are created by entrepreneurs through an emergent and iterative search process, that differences between entrepreneurs and non-entrepreneurs are created through by this search process, and that the decision making context within which entrepreneurs operate is either ambiguous or uncertain.

Creation opportunities

The theory indicates that opportunities do not exist objectively, but emerge as individuals explore ways to generate economic wealth (Sarasvathy, 2001). Therefore, in the Creation Theory, opportunities are created by individuals who are searching for ways to gain real economic wealth. However, this search process is not governed by profit maximizing and cost minimizing logic (Kohn & Shavell,1974).

The concept of emergent opportunities closely links the study of entrepreneurship with the theory of learning (Dodgson, 1993). According to the Creation Theory, as entrepreneurs begin exploring a possible opportunity, they learn that their original hypotheses about the nature and scope of the opportunity are not justified and are forced to develop new hypotheses and so forth (Sarasvathy, 2001).The process of searching for new opportunities does not lead an entrepreneur to discover real opportunities for creating real economic wealth. Despite the difficulties, the Creation Theory suggests that some individuals may emerge from the search process with clear understanding of an opportunity that has the potential to generate real economic wealth, not the opportunity they thought they were going to exploit.

Creation Entrepreneurs

In the Creation Theory, individual differences between entrepreneurs and non-entrepreneurs are more likely to reflect the different experiences of these two groups over time rather than inherent differences between the groups (Sarasvarthy, 2001). Therefore, the Creation Theory suggests that not only do entrepreneurs create opportunities through emergent search process, but creates the entrepreneur as well. In this theory, the entrepreneur is not necessarily different before creating the opportunity but emerges with differences as a result of the process of creating opportunity.

Creation Decision making context

The Creation Theory assumes that decisions made by entrepreneurs are usually made under conditions of ambiguity or uncertainty. A decision making is defined as ambiguous when the possible outcomes of a decision are known before the decision is made, but the probability of those outcomes are not known, at the time the decision is being made (Dequech,1999). Decision under uncertainty occurs when neither the possible outcomes, nor the probability of those outcomes, are known when the decision is being made (Alvarez & Barney,2005). In both cases it implies decision making with less than perfect information about the outcome of a decision.

Relevance of the theories to the study

The current study looks at water hyacinth alone and when it is mixed with sawdust as a new area, discovery of new business opportunity is emphasized. However, this comes with some level of risks which can be exploited by entrepreneurs to create wealth. Opportunities are known to be fleeting and time should not be wasted when they appear. Therefore, water hyacinth and sawdust substrate anchors in these theories

The theories emphasize the development of business plans within the business context. The fundamental objective of an entrepreneur is to create economic wealth which this study intends to promote by developing the product and evaluating economics (Benefit-cost analysis). In the Discovery Theory settings,entreprepreneurs will put together plans that actually guide their business decisions, while in the Creation Theory settings, they will constantly be adjusting the fundamental assumptions of the plan. Therefore, the conditions and situation would be evolving from one theory to the other and vice versa.

The water hyacinth on Lake Victoria, Lake Naivasha and Nairobi Dam, presents a business opportunity to be exploited to create economic wealth. Robert et al. (2009), define a business opportunity as representing a possibility for the entrepreneurs to successfully fill a large enough unsatisfied need that results in sales and profits. Business is referred to as an economic activity which is primarily organized and directed to produce goods and services at a profit (Kibera, 1996).

2.3 Mushroom

A mushroom is defined as a macrofungus with a distinctive fruiting body which can be either epigeous (growing on the ground) or hypogeous (growing underground).The macrofungi have fruiting bodies large enough to be seen with the naked eye and can be picked up by hand (Mushworld,2004). It requires an organic substrate which is rich in nutrients, particularly Nitrogen, Phosphorous and Potassium (Aboud et al., 2005; Rogers &Davis, 1972). The material has also to be rich in Lignin and Cellulose, which form nutrition to mushroom mycelium (Kimenju et al., 2009).

2.3.1 General information about mushroom

The mushrooms were initially classified as vegetables for many years. During the second half of the 20th century they were grouped into a separate kingdom known as fungi kingdom, since they are neither true vegetables nor animals (George & Pamplona, 2004). The life cycle of mushroom is divided into two phases; Vegetative and reproductive growth. Vegetative growth indicates linear growth of fungal mycelia dissolving complex substrate into simpler molecules and absorbing them as nutrients. Reproductive growth is when the actual mushrooms are produced. The mushroom can be classified into three categories by their tropic pattern namely Saprophytes, Parasites and Mycorrhizae (Mushworld, 2004). Most of the common mushrooms fall under Saprophytes, growing on organic matters.

The species of fungi globally are estimated at 1.5 million, and only 64,000 species have been described so far (Oei, 2003). Many species from tropical rain forests and remote areas may have disappeared before science had the opportunity of describing them. About 10,000 species produce the fruiting bodies which are called mushrooms, and approximately 300 types of edible mushrooms and about 30 types have been domesticated/cultivated (Chang & Miles, 1997).

There are two types of mushrooms namely edible and medicinal. Some of the medicinal mushroom species include *Ganoderma lucidum* and *Ganoderma tsugae*. Researchers have established medicinal attributes in some mushrooms like antiviral, antibacterial, antiparasitic, antitumor, antihypertension, antidiabetic, anti-inflammatory and immune effects (Wasser & Weis,1999). They are now considered as genuine nutraceuticals, from which nutriceuticals and pharmaceuticals can be developed. Some of the mushrooms which have been domesticated include several edible and medicinal species such as Agaricus, Lentinula, Pleurotus, Volvariella, Auricularia, Flammulina, Tramella, Hypsizgus,Pholiota, Grifola and Hericium (Martinez et al.,2000). The nutritive value of mushroom consists of several vitamins, minerals, proteins, carbohydrates and free of cholesterol(Pamplona-Roger,2006).

Environmental growing conditions for mushrooms have to be observed and managed well. The critical conditions which can affect mushroom production adversely include temperature and relative humidity at all phases of growth such as spawn running, fruit induction and harvesting (Kivaisi, 2007). Table 2.2.1 below shows the two environmental growing conditions at all growing phases.

Table 2.2.1: Critical Environmental Growing Conditions for Mushrooms

Spawn running	
Temperature (^oC)	29+2
Relative humidity (%)	79+1
Fruit induction	
Temperature (^oC)	28+1
Relative humidity (%)	79+1
Harvesting	
Temperature (^oC)	30+2
Relative humidity (%)	78+1

Source: Kivaisi Report, 2007.p33

2.3.2 Importance of mushrooms production in economic development

The Millennium Development Goals (MDGs) focus poverty reduction as one of the major priority areas. This is aimed at reducing the proportion of people living in extreme poverty by half by 2015 (Okemo, 2001). The expansion of the mushroom industry could contribute to MDGs which is a global concern. Odendo et al. (2014) indicate that mushroom is a high value niche product with great potential to contribute to enterprise diversification and poverty alleviation by utilizing agricultural wastes.

The study conducted by Kharbikar et al. (2011) in India found that mushroom production contributed to income generation by13.9% and created employment opportunity by 7.1%, among the enterprises evaluated (Table 2.3.2). The contribution of oyster and button mushroom figures has been added together since both are mushrooms. The findings are a clear demonstration that mushroom production contribute substantially to economic development of India. This is an indication that countries which could adopt or promote mushroom production technology will have an impact on their economic development.

Table 2.3.2: Income and employment impact after adoption of mushroom production technology.

Enterprise	Annual income (Rs)	Income Distribution (%)	Annual employment generation (Days)	Employment generation (%)
Agriculture	26816	48	180	55.2
Animal Husbandry	12266	22	119	36.5
Oyster mushroom	1572	3.1	10	3.1
Button mushroom	5404	10.8	13	4.0
Value addition	9321	17.0	4	1.2
Total	5008	100.0	326	100.0

Source: Kharbikar et al., 2011

2.3.3 Mushroom Cultivation

Mushroom production is not a recent development in the world. Mushroom has been part of human diet since time immemorial (Tricita & Quimio, 2004). They were used as food and for medicinal purposes even before man understood the use of other organisms (Sigot, 2010). Mushrooms were often considered an exotic and luxurious food reserved for the rich only. Hippocrates first mentioned about mushroom when he wrote about their medicinal value in 400 BC. The first mention of mushroom cultivation, distinct from chance appeared in the field in 1652 B.C.The cultivation of mushroom from natural occurrence led to cultivation theory.

2.3.4 Mushroom Cultivation Theory

Martinez et al. (2000) has given a historical background about cultivation of mushrooms. The first successful cultivation of Psilocybian mushrooms from Mexico was accomplished by the French mycologists, Roger Heim and Roger Cailleux in Paris during the late 1950s. The roots of Psilocybian cultivation techniques go back to 18^{th} century in France, when Agaricus (White button) mushrooms was first cultivated using horse manure as substrate, also referred to as a medium of mushroom production.

The first book on mushroom cultivation was written by Falconer (1891), who was a mushroom grower and experimenter. The book shed new light on the theory of cultivation of mushrooms on horse manure compost as a substrate. Falconer's book is still among the most informative publications for home cultivators of potent Psilocybian mushrooms. The empirical methods for Auricularia spp. and lentinula edodes cultivation was developed in China about 1000 years ago.

After successfully cultivating mushrooms using organic materials the search for other suitable medium (substrate) of mushroom cultivation continued. Pollock (1977) tried using a mixture of wheat straws and corn debris (Leaves and stalks) to grow mushroom, however, more mushroom flushes were obtained from Corn debris alone .The researcher further identified other media such as brown rice which he concluded as the most available, most economical, and therefore most convenient substrate for home mushroom cultivators.

Quimio (2002) found that oyster mushrooms are suited throughout the third world areas that are rich in plant waste such as sawdust, sugarcane bagasse and others which can be used as substrates. A study by Gibriel et al. (1996) indicated that oyster mushroom has a high colonizing ability and can grow on virtually any agricultural waste than other mushrooms. This explains why oyster mushroom is often preferred for cultivation by majority of mushroom growers especially the starters. Therefore, the cultivation theory has led to domestication of mushrooms using locally available organic materials.

The mushroom cultivation theory has made researchers to continually investigate the suitability of locally available organic materials for mushroom production (Martinez et al., 2000). Based on the selected materials, it enables the researcher to estimate with some level of precision the yield potential of mushroom from a given organic material. Consequently, estimation of income expected has been made much easier. Moreover, the approach helps mushroom consumers to avoid eating poisonous mushrooms found growing wildly.

2.3.5 Substrate availability

Hyunjong and Byung (2004) defined substrate as organic material on which the mycelium of mushrooms grows or the medium for growing mushroom, just like soil, is to plants. Also Tedesse (2012) has defined substrate as a kind of lignocellulogic material which supports the growth, development and fruiting of mushroom mycelium. This organic material has to be rich in nutrients mainly Nitrogen, Phosphorous and Potassium. It also has to be rich in Lignin and Cellulose which are utilized by mushroom mycelium which is considered as vegetative part of mushroom (Kimenju et al., 2009; Aboud et al.,2005; Rogers & Davis,1972). Zandrazil & Kurtzman (1982) argues that if there is no substrate, definitely there will be no mushroom.Therefore, any organic matter with these attributes will be a good substrate for mushroom production.

Mushroom production is completely different from growing of green plants. They do not contain chlorophyll. Therefore, they depend on other plant materials for their food (Alice & Michael, 2004).There is enormous amount of waste globally in the agro-industry and the wood industry.Annualy, available world waste in agriculture is about 500 billion kg and forestry has about 100 billion kg, able to produce 360 billion kg of fresh mushrooms (Chang & Miles, 1989).

Poppe (2000) conducted a worldwide survey focusing on suitable substrates for mushroom cultivation and recorded 200 kinds of waste that have been proved to be useful for growing oyster mushroom. These come mainly from agricultural and forestry (Agro-Forestry) residues, available for small or large scale cultivation of oyster mushrooms .The extent of utilization of these materials depend on their availability in abundance and suitability. The commonly used substrates from agricultural waste include all the cereal straws, corncobs, sugarcane bagasse,coffee residues, and banana frond (Dietzler,1997).However, bagasse by-product of sugarcane is considered as the best substrate(Wachira,2003).

Fermont *et al*.(2008).indicates that the agricultural waste as a major source of substrate for mushroom production has limitation concerning its availability in Kenya just like any other country. This is because the Kenyan population is in a continuous increase against a declining acreage of arable land. Consequently, the available arable land is being subdivided into smaller parcels which are intensively cultivated. The ultimate result has been a decline in agricultural productivity and sustainability of agro-ecosystems (Statistical Abstract, 1999). In addition to decline in productivity, availability is dependent on seasons (Kivaisi, 2007). Most of agricultural activities take place during the rainy season, hence affecting their availability throughout the year. Therefore, the above studies have confirmed that agricultural and forestry wastes are unreliable for the mushroom industry because these sources are affected by seasonality and scarcity of land due to population pressure on land. Bagasse and sawdust organic materials are commonly used for oyster mushroom production, hence a brief situational analysis has been highlighted below.

2.3.5.1 Bagasse substrate situation

Wachira (2003) has indicated that bagasse has been identified as the best substrate for mushroom production. However, its availability is diminishing fast from the sugar industry. The major alternative use is currently in the production of electricity. The establishment of cogeneration plants, new technology which uses it as feedstock or raw material increases competition for bagasse availability (Kerekezi & Kithyoma, 2005; Kerekezi, 2002). Yuko (2005), states that the bagasse is preferred in the production of electricity because the cost is lower compared to using fossils. The rate at which bagasse is currently being depleted is very fast due to cogeneration plants (Owino, 2009). Additionally, arable land suitable for sugarcane is being reduced due to population pressure on land (Fermont et al., 2008).

The shortage of bagasse will continue to be experienced due to the desire by many sugar factories to produce electricity for their internal consumption and selling to national grid to generate extra income. Consequently, the mushroom industry will be affected or face imminent collapse if the mushroom industry keeps relying on this source for mushroom production.

2.3.5.2 Sawdust substrate situation

The sawdust is a by- product of lumbering or wood industry. Poppe (2000) has enlisted sawdust among the 200 types proven as good substrate for mushroom production despite some limitations. The study by Spelter (2008), showed that sawdust has been put into many uses because of innovations such as bedding for the animals and biomass for power plants. Shortages have also been caused by the closure of sawmills (Vancourver, 2008; Spelter, 2008). Tom (2003) has indicated that deforestation is one of the causes of sawdust shortage.Hyung & Brung (2004), indicated that not all tree species can produce suitable sawdust for mushroom production. For instance pine has resins which inhibit mycelia growth, Cedar and redwood resist mycelia colonization. Therefore, relying on sawdust alone as a substrate for mushroom production may lead to depressed production.

In Kenya desired forest cover area is 10%, but currently it covers only 2% (Gari, 2011). The demand for trees is being met by importation from DR Congo, Tanzania and Uganda (Siele,2011).Wamukoya (1995),has shown that sawdust is being used for the manufacturing of briquette which is a possible source of fuel .

Despite the many uses to which sawdust has been put, the existence of wood industry gives an assurance of sawdust being available even if in small quantities. The small quantities being generated cumulatively could result into large volumes. This, to some extent, can sustain the mushroom industry. Kenya Agricultural and Livestock Research

Organization (KALRO) formerly referred to as KARI, evaluated performance of oyster mushroom on sawdust substrate (KARI, 2011). The findings are indicated in table 2.3.5.2 below.

Table 2.3.5.2: Performance of Strains of Oyster on sawdust Substrate

Strain	Opening to 1st flush(Days)	Yield/Flush(Gm)					
		1st	2nd	3rd	4th	5th	6th
P.Sajor.caja	30	67	30.0	3.8	2.4	0	0
P.quebeca	35	53.4	24.0	7.9	0	0	0
P.burundii	7	18.9	0	0	0	0	0
P.oesteatus	8	67.0	36.0	30.0	19.0	0	0
P.oesteouts	12	70.0	29.0	9.9	1.7	0	0
P.eous Kapak	4	72.0	37.0	40.0	7.3	10.1	6.5
P.eous PD-4	5	72.0	48.0	15.0	1.4	3.0	0

Source: KARI, Report, 2011

2.3.6 Mushroom Production trends

According to Chang (1999) the world production of edible and medicinal mushrooms has been on an upward trend. In 1965, about 350,000 metric tons were produced and by 1997, there was 6,160,800 metric tons. This shows that in a period of 32 years, the production increase was 181,587.5 (51.9%) metric tons annually. Beharilal (2014) has also shown that the expansion witnessed is both horizontal and vertical, meaning an increase in mushroom production and addition of newer types of mushrooms for commercial production comprising of edible and non-edible mushrooms. Chang (1999) indicates that in oyster mushroom production globally, China is the leading and Africa is the least (Table 2.3.6a, b).Therefore, to increase mushroom production in Africa and consequently create wealth, continuous research on suitable substrates should be considered as a top priority. What drives or motivates an entrepreneur most to pursue an opportunity is the creation of economic wealth (Helfat & Barney, 2004). Kibera (1996) in his study showed that mushroom production is an economic activity which can create economic wealth and employment opportunity.

Table 2.3.6a: Estimated Production (Fresh weight) of Oyster Mushroom in 1997

Country	Production(1000m)	Production(1000lb)	%
China	760.0	1675496	86.8
Japan	13.3	29321	1.5
Rest of Asia	88.4	194887	10.1
North America	1.5	3307	0.2
Latin America	0.2	441	-
European Union(EU)	6.2	13668	0.7
Rest of Europe	5.8	12737	0.7
Africa	0.2	441	-
Total	875.6	1930348	100.0

Source: Chang, 1999

Table 2.2.6b: Mushroom production in China and in the world (Metric tons)

Year	World	China	China/World (%)
1978	1060	6.0	5.7
1986	2176	585	26.9
1990	3763	1000	26.6
1994	4909	2640	53.8
1997	6158	3415	55.5
2000	-	6630	-
2002	12250	8630	70.6
2006	-	14000	-
2008	26000	18200	70.0

Source: Mushroom business, 1/5/2010

The United States Department of Agriculture (2002) report indicates that the United Nations estimated world mushroom production to be over 2.96 million metric tons (Appendix.111). In this report, China is still shown as the world's largest producer, accounting for approximately 42 per cent of the world production. The United States is the second largest producer, followed by the Netherlands and France. Together, these three nations account for about 28 per cent of production.

According to USDA (2002), there is an increased demand in consumption and production of mushroom. The increase evidenced in mushroom production has been attributed to relatively high compensation growers/farmers receive for the product from the government (Appendix.1V).The compensation can be seen as a motivation to growers in that more people would be engaged in mushroom production. This motivation in terms of subsidy provision is often lacking in most of the developing countries which are largely found in Africa, therefore resulting in low mushroom production.

In Japan, Katsuji (1997) showed that, the highest production level of mushrooms was in 1994 but this started to decrease because of a high cost of production and imports from China. The decline in production has largely been attributed to the shortage of sawdust substrate. Sawdust in Japan is the main source of substrate for mushroom production and decline in availability has been caused by alternative uses to which sawdust has been put.

In Africa mushroom production for either the local or external markets is in most countries at its infancy stage (FAO, 2002). It is only South Africa, Zimbabwe and Kenya that have been reported to produce mushrooms on a commercial scale.

In East Africa, production of mushroom is on the increase although the expansion rate is slow. According to Kivaisi (2007) Mushroom production was first introduced to Tanzania in 1993 by the Ministry of Agriculture and Cooperatives under the Sponsorship Fund for Agricultural Development. The focus was on cultivation of oyster mushrooms, common type of mushroom in Tanzania. The project established about 4000 smallholder mushroom farmers in 10 regions which are estimated to produce a total of 960 tons of fresh mushrooms annually. Despite this result, the project is faced with the challenge of availability of reliable source of substrate since most of the agricultural waste is seasonal.

According to Wambua (2004), Kenya has a potential of producing over 100,000 tons of mushroom every year. However, current mushroom production is estimated at 500 tons per annum which is far below the potential while the consumption is estimated at 650 tons thereby creating a shortage of 150 tons. The shortage is often met by importing from countries whose production is high like China (Dinghaun & Xiaoyong, 1978). The probable reason for the low production of mushroom could be attributed to inadequate substrate availability.

Sigot (2010) has indicated that the mushroom industry in Kenya is still in its infancy stage. To the majority of people in Kenya, mushroom cultivation is still a myth because there is lack of communication between the researchers in this field and the farmers/growers. This is true because the finding of Kimenju et al. (2009) on suitability of water hyacinth substrate for mushroom production has not been communicated to mushroom growers.

2.3.7 Mushroom production in Vihiga Mushroom Project

Bertil and Gunilla (2000) initiated Rivendell Mushroom Project at Rivendell Gardens in Shinyalu division of Kakamega Sub-county (Formerly Kakamega District). The aim was to assist poor farmers to create extra income, extra food and create employment. Unfortunately the project collapsed immediately the initiators left the country to Sweden. However, the idea was later adopted at Vihiga County formerly Vihiga district by a community based organization known as Vihiga Mushroom Project (Vimpro).

Family Concern (2005) describes Vihiga Mushroom Project as a community based organization which was initiated by Vihiga farmers with the help of the Ministry of Agriculture in the year 2002. The district is highly populated with poverty levels of 62%, leading to very high pressure on land. Most of the farmers own less than ¼ an acre of land for agriculture, which is in most cases overused. The government, through the Ministry of Agriculture, encouraged farmers to start growing mushrooms as an alternative to other forms of farming. The fact that commercial mushroom production could take place on a very minimal area of land motivated many peasant farmers to form groups and start production, hence it became one of the main economic activities of the farmers affiliated to Vihiga Mushroom Project aimed at job creation, income generation and food security.

After its inception in 2002, the project obtained some funds from Constituency Development Funds (CDF) and other organizations to finance mushroom activities (Family Concern, 2005). The Vimpro has an estimated population of 16,800 smallholder farmers registered in 115 mushroom cultivation project groups. However, those in production are 12 groups with membership of at least 100 per group (Sigot, 2010). This implies that103 groups representing 89.6% dropped mushroom production. The most likely reason for this large number dropping mushroom production could be inadequate substrate because the arable land is scarce.

Family Concern (2005) indicated that bagasse as a substrate for mushroom production was supplied to the project by Mumias Sugar Factory. The economic activities of the growers in the project were hindered by the unexpected problem of suspension of sugarcane bagasse supply from the factory.Mumias Sugar Factory stopped supplying sugarcane bagasse in 2009. Sugarcane bagasse had been previously dumped by the factory, so the project could get the substrate material for free. However, the factory stopped disposing of the bagasse after it found that the waste could be utilized by the power cogeneration plant. This caused a serious problem for the project leading to depressed production. The annual production reports (Appendix VI) showed that mushroom production in 2009 was 73370kg (fresh) and 56kg (dry) which dropped to

1782 kg(fresh) by 2011, a reduction of 97.4% and increased to 95kg (dry) while there was no mushroom production in 2012 due to shortage of bagasse among other constraints.

2.3.8 Mushroom Market demand in Vimpro

The survey by Family Concern (2005), found that market demand of mushroom per capita was 1.54kg per adult equivalent, and projected the potential demand at 30800 tons annually (Table 2.3.8). The study also predicted an increase in consumption of at least 10%. The respondents of the study, 83.8% of them indicated that they were willing to consume more mushrooms if the mushrooms are made available at affordable prices. This implies that there is ready market for mushrooms. However, adequate production to meet the demand remains a challenge.

Table 2.3.8: Meat Per Capita Consumption Compared to Mushrooms

Consumers	Beef(Kg)	Mushrooms(Kg)
Lower class	9.0	0.9
Middle class	16.0	1.6
Upper class	21.19	2.12
Average	15.39	1.54

Source: Family Concern, 2005

In an attempt to promote mushroom production in Vihiga Mushroom Project, there is need therefore to identify an alternative material for partial or complete replacement of bagasse. A possible potential substrate identified for oyster mushroom production was the water hyacinth (*Echhornia crassipes)*. This prolific aquatic weed is locally available in abundance from Lake Victoria (Obiero et al., 2001).

2.4 Water Hyacinth

Aboud et al. (2005) describes this aquatic weed as a flowering, thick floating mat, and freshwater plant. It has beautiful, large, pale-blue flowers with purple and yellow spots on the petals and shiny round green leaves (Navarro & Phiri, 2000). It often occurs in nutrient rich aquatic environments such as lakes, reservoirs and fresh water streams.

2.4.1 Origin, Nature, Spread and Quantity available of Water hyacinth

Tom (2003) shows that water hyacinth originated in Latin America, and is believed to have been introduced to Africa in the 19th century by Belgian colonists who wanted to adorn ponds with it. Currently, it has proliferated across the lakes and rivers of Central and Eastern Africa.

Peggy (n.d) has outlined a number of characteristics of water hyacinth which makes it succeed in its new habitats. Water hyacinth reproduces effectively through the process of fragmentation. The process can be caused by the churning propellers of motor boats, the trashing of swimming animals, tossing around by wave action during storms. They can also reproduce by forming plantlets at the end of a shoot that grows from the base of the stems. These stems are spongy and filled with air spaces which allow them to stay afloat easily. The leaves are fanlike and slightly cupped, making it very effective to sail and allows the plants to spread easily over water bodies when the wind blows. The roots have a feathery network enabling them to gather nutrients from the water very easily.

According to Evans (1963), the spreading of water hyacinth has been aided by various agents such as tourists, botanists and animals. Due to its beautiful blooms and foliage, tourists, plant collectors and botanists have carried the plant to over 80 countries around the world in the last 100 years. It is also known that birds and animals that feed in sites of water hyacinth infestation transport the seeds over considerable distances on their own feet. A sample survey of 29 AME countries indicated that most of these countries have water hyacinth, and 21 of them have confirmed that the weed is already a problem within their borders.

In Africa Water hyacinth was initially recorded in Zimbabwe in 1937,(Eglal & Dina,2000). It has continued to colonize important water bodies in the country. In Kenya the first case of water hyacinth was reported in lake Naivasha in 1988(Njuguna, 1991) and Lake Victoria in 1997 (Mailu, 1999). By early 1989 the plant had progressively spread in Lake Naivasha and in 1992 it became the dominant weed species (Harper et al., 1991). So far, the weed has adversely affected lake transport and the fishing industry in both lakes. Navarro and Phiri (2000) indicated that by the year 2000, it had covered an area of 12000ha in Lake Victoria and within the span of 13 years later, it had aggressively progressed to an area of 68,000ha, equivalent to 680.km^2(Oketch, 2013).The plant is known as the world's fastest growing water-borne weed with ability to double its biomass in less than two weeks (Lewis, 2002). A single plant can produce 3,000 others in 50 days, and cover an area of 600 m^2 of water surface in a year (James, 2002).

Aboud et al. (2005) found that water hyacinth can yield 322.2 tons of biomass from one hectare per year while Obiero et al. (2001), reported that the plant is capable of producing 10 million metric tons of dry biomass every year from Lake Victoria. McGrath (2003) has expressed his opinion that there is an opportunity of expanding mushroom cultivation in Africa due to the presence of water hyacinth. All these studies show that water hyacinth is a potential substrate if used in mushroom production can lead to rapid expansion of the mushroom industry.

2.4.2 Socio-economic consequences of water hyacinth

Mailu (2001) has reported the impacts of water hyacinth in Lake Victoria on social, economic and environment for millions of people in riparian communities. The importance of water hyacinth stems from its potential to produce negative consequences on the water bodies(lakes and rivers), consequently affecting economic activities of the riparian communities who depend on them. The adverse impact of the excessive growth of water hyacinth is being felt in the economics of Zimbabwe, Malawi, Zambia, Tanzania, Kenya and Uganda. The weed causes a variety of problems when its rapid mat-like proliferation covers areas of fresh water. Because of these problems, the weed has been perceived widely as an enemy to be destroyed, with little regard on economic value. Some of the common problems are outlined below.

Access to harbors and docking areas can be seriously hindered by mats of water hyacinth. Canals and freshwater rivers can become impassable as they clog up with densely intertwined carpets of the weed. In his speech, Mohammed (2011) said, “We are looking into ways of reducing the amount of chemicals that get into the lake waters leading to the spread of the hyacinth”. Boats and ships engaged in fishing activities use up to ten times the normal amount of fuel to navigate through the weed. In his article, Gitonga (2011) indicated that tour operations in Lake Naivasha had been grounded due to the water hyacinth which covered the lake.

Navarro&Phiri (2000) have outlined other consequences of water hyacinth in Africa and the Middle East as: clogging of intakes of irrigation, hydropower, water supply systems, blockage of canals causing flooding and micro-habit for a variety of disease vectors. For instance the Owen falls hydropower scheme at Jinja on Lake Victoria is a victim of the weed’s rapid reproduction rates. An increasing amount of time and money has been invested in clearing the weed in an effort to prevent it from entering the turbine and causing damage leading to power interruptions. Water hyacinth can grow so densely that a human being can walk on it. When it takes hold of rivers and canals, it can become so dense that it forms a herbivorous barrage, consequently causing damage and dangerous flooding which can interfere with farming activities. The diseases associated with the presence of aquatic weeds in tropical developing countries are among those that cause the major public health problems. The diseases carried by mosquitoes (malaria) or snails (biharzia) that breed in water-hyacinth environments. Thus leading to reduced labour productivity in both crop production and fishing activities.

Phiri (1997) has indicated that various studies have been carried out to ascertain the relationship between aquatic plants and the rate of evapotranspiration compared with evaporation from an open-surfaced water body. Sudan has partially evaluated the socio-economic costs of water hyacinth, estimating that the annual water loss from evapotranspiration over 300m^2 of canal would be enough to irrigate more than

400ha.Saelthun (1994), suggested that the rate of water loss due to evapotranspiration can be as much as 1.8 times that of evaporation from the same surface area. As a result water resource become scarce for irrigation, hence leading to depressed crop production activities.

Gitonga (2011) has shown that water hyacinth can present many problems for the fishermen. Access to sites becomes difficult when weed infestation is present, loss of fishing equipment often occurs when nets or lines become tangled in the root systems of the weed. The result of these problems is more often than not, a reduction in fish catch consequently creating unemployment, diminished incomes and food for riparian communities. Fish traders are now importing fish from Tanzania and Uganda (Mohammed, 2011).The fish production in Lake Naivasha has been reduced by 50%. The fishers have reported that they are often bitten by venomous snakes hiding and attack by crocodiles taking shelter in water-hyacinth mats.

Phiri(1997) has reported that the range of problems with water hyacinth infestations is in general terms widely known and expected, the real impact on the socio-economic status and welfare of the people who depend on the affected water has been neither well analyzed nor well documented. This is one of the most certain explanations as to why the water-hyacinth problem is still poorly understood by many researchers. Where water hyacinth is prolific, other aquatic plants have difficult in surviving. This causes an imbalance in the aquatic micro-ecosystem and often means that a range of fauna that relies on a diversity of plant life for its existence will become extinct. This means that local plants and animals will lose their habitats. Diversity of fish stocks is often affected with some benefitting and others suffering from proliferation of water hyacinth. Mats block light from penetrating river water, which induces changes in the flora and fauna underneath, sometimes hindering fish production.

2.4.3 Available control measures for water hyacinth

Narro and Phiri (2000) gave three basic techniques aimed at controlling water hyacinth which include mechanical, biological and chemical. Chemical control is least favored owing to the potential damage that the herbicides could cause in the lakes and surrounding agriculture. Mechanical removal has been attempted but is largely ineffective. The recurrences of water hyacinth in various countries where the techniques have been applied is an indication of their ineffectiveness. Some of the countries affected and efforts made to control the weed are outlined below.

In Egypt, people distributed water hyacinth as an ornamental plant for public gardens in the vicinities of larger towns, such as Cairo and in Nile Delta in the late 1890s and early 1900s (Muschler, 1912; Gopal, 1997). In 1983 the infestation in river Nile between Aswan and the Mediterranean Sea reached a peak of 8400ha. The country started to control the weed using chemical, biological and physical means which resulted into reduced infestation level to about 380ha in 1992. The country also stopped use of chemical in about 1990-1991 because of environmental concerns. The findings in 1996 show that the level of infestation had increased again to 5000ha (Navarro & Phiri, 2000). Therefore the weed has not been controlled effectively using the three basic techniques, therefore remains a menace in Egypt.

In Sudan, the weed was first discovered near Bor town about 1954, presumably having invaded from the Congo River, where it had spread since 1952. In 1958-1959, Sudan declared it a pest, like the desert locust and Quelea birds that feed on grain, and then put legislation in place to control it. Water hyacinth breeds continuously around Juba-Malakal, is discharged through Malakal-Kosti and is lodged over a further 300km down the Nile. The country has partially evaluated the socio-economic costs of water hyacinth, estimating that annual water loss from evapotranspiration over 300km^2 of canal would be enough to irrigate more than 400ha.Its effects on navigation in the Nile include 50% higher running and maintenance costs and 30% more fuel usage (Phiri,1997; Navarro & Phiri, 2000). The country initiated efforts to combat the weed in 1959 using chemical (Herbicide, 2-4D), biological and physical. The finding on chemical cost was almost 1.5million USD annually, hence terminated chemical control in 1983. Therefore, water hyacinth in Sudan was partially controlled.

In Nigeria, the water hyacinth was recorded for the first time in 1984 in Badagry Creek. Presumably, it had spread from neighboring Benin where it had been reported earlier. The weed has spread to most rivers of Southern Nigeria and to Lake Kainji in Niger State. Lake Kainji is important for hydroelectricity production. The rapid spread of the weed in Nigeria is attributable to human transportation and to the interconnection of fresh water bodies (Navarro &Phiri,2000).

In trying to control the weed, Nigeria government formed a national committee on water hyacinth whose main objective was to monitor the development of the weed and implement mechanical, chemical and biological control measures (Navarro & Phiri, 2000). The findings indicates that manual removal (mechanical) has been unsuccessful and chemical control was discontinued due to environmental concerns and also biological method using imported water hyacinth weevil, *Neochetina eichhorniae* which was released into the Niger River in 1993 has not been successful. Therefore the weed has not been controlled successfully.

In Benin, initial infestation of water hyacinth appeared in the Queme River in 1980-81 but reached outbreak proportions in 1985(Navarro & Phiri, 2000). This river produces about 24000 tons of fresh fish on average annually and provides livelihood for about 34360 full-time fishers, but infestations of water hyacinth threaten this livelihood greatly (Phiri , 1997). In trying to control the weed, the country has relied almost exclusively in biological control measure. Two weevil species were introduced between 1991 and 1995 namely *Neochetina eichhorniae* and *Neochetina bruchi*. The findings revealed that there is no evidence on whether biological control has been a success. Consequently, the weed is still a menace in the country.

In South Africa, the water hyacinth was first reported in Natal in 1910 and from there it has spread throughout S.Africa. About 20000ha of the weed is found on rivers and artificial water bodies throughout the country. The country has legislation that covers water hyacinth, the conservation of Agricultural Resources Act (Act 43 of 1983). The Act declares water hyacinth as a weed that must be controlled (Phiri, 1997). An effort to control the weed was initiated in 1962 and relied mainly on chemical control and to a lesser degree on physical measure. In the Vaal River, Aerial herbicide application was carried out between 1983 and 1985. The findings indicated that in 1985-86, the river became reinfestated and water hyacinth blocked large stretches of the river. Moreover, in 1974, biological control was initiated by importing and releasing the weevil *Neochetina eichhorniae* which was not effective. Navarro & Phiri (2000) have concluded that more research is required on effective control measures.

In an effort to control water hyacinth in Kenya, the government has tried to use mechanical and biological control measures which have not been successful. The spread of water hyacinth in Lake Victoria when it reached a crisis level, the economic activities in the lake were interrupted greatly. In his article, Athembo (2011) refers to the basic techniques used to control it as, 'Repetition of failed past efforts to control the hyacinth'. Athembo (2011) continues to argue that water hyacinth deserve to be treated as an important natural resource.

Kisumu County intends to start electricity project using water hyacinth as raw material through Korce, a research firm(Oketch,2013).The project is to cost kshs100 million and will generate 120 megawatts to national grid. The hyacinth-harvesting machine has been bought and the project is being put up on 40-acre land. This is a promising initiative, however, it seems that hyacinth- harvesting machine might facilitate the propagation of hyacinth faster than motor boats, since the weed reproduces effectively through the process of fragmentation (Peggy, n.d). Therefore water hyacinth remains a problem in Kenyan lakes.

2.4.4 Water hyacinth substrate as a replacement of bagasse for production of oyster mushroom

The first attempt to cultivate mushrooms using the water hyacinth as a substrate was made in China. Chang of the Chinese university of Hong Kong was the first to demonstrate that water hyacinth substrate can be used in growing mushroom (McGrath, 2003). In his article, McGrath (2003) outlined the work of Tagwira from Zimbabwe, a laboratory technician at the African University of Mutare in Zimbabwe, who picked up this knowledge and started establishing demonstration farms. She has been credited with turning a problem into an opportunity. Having succeeded in growing mushroom on water hyacinth substrate, Tagwira set about testing whether their commercial production was a viable proposition. Within a few months, a demonstration farm was yielding 40 to 50kg of mushroom per day, worth about US dollar 55 -70 on local market. Since Tagwira managed to grow oyster mushroom using water hyacinth, it was concluded that the water hyacinth is a good substrate for oyster mushroom production.

Kivaisi et al. (2004) conducted an experiment to study the performance of *Pleurotus flabellatus* using water hyacinth shoots at two different temperature and relative humidity in Tanzania. The objective was to determine the suitability of the weed for growing the domesticated strain (*Pleurotus flabellatus*), at two places with different temperature and relative humidity regimes (18-25/27-29^{O}C and 55-85/79-93%), at Dar es Salaam and Moshi (Table 2.4.4a).The result showed that there was better performance of mushrooms at high temperature and relative humidity at DSM than at lower temperature and relative humidity at Moshi. The study concluded that water hyacinth shoots proved to be a good substrate for growing the local oyster mushrooms at ambient environmental conditions.

Table 2.4.4a:Rate of growth and yield of mushroom in Moshi and Dar es Salaam

Place of Growth	Time to full myacelia Colonization	Time to primordial appearance	Mushroom Yields(Gms)				BE (%)
			1st Flush	2nd Flush	3rd Flush	4Th Flush	
Moshi	10	15	159(*19)	402(**3)	80(**4)	None	55.3
DSM	7	10	362(*13)	378(**3)	199(**4)	31(**6)	84.8

Source.Kivaisi et al., 2004

*In brackets are days to first flush

**In brackets are days in between the flushes

Kimenju et al. (2009), in their study on suitability of locally available substrates for oyster mushroom cultivation in Kenya, proved that water hyacinth is a good substrate. In this study, ten selected substrates among them water hyacinth (*Eichhornia crassipes*) and sawdust (Eucalyptus sp) were evaluated (Table 2.4.4b). The objective for the study was to determine the suitability of locally available substrates for oyster mushroom production. The results showed that the organic substrates were significantly different in suitability for mushroom production. It was concluded that many organic substrates had high potential for utilization as substrates in mushroom production.

Table 2.4.4b:Effect of substrate on yield per flush and percentage of yield per flush

	Yield per flush(g)			Percent Yield per flush		
Substrate	1st	2nd	3rd	1st	2nd	3rd
Banana Fibre	83.8	49.9	26.2	54.2	31.1	14.9
Bean straw	145.5	66.4	44.7	57.2	25.6	17.3
Coconut fibre	25.7	13.8	14.3	49.3	27.2	23.5
F/ Millet straw	96.5	48.4	50.3	49.6	24.6	25.8
Maize cobs	40.4	14.0	6.4	67.0	23.1	9.9
Rice straw	101	69.4	49.2	48.2	31.2	20.6
Sawdust	5.5	0.8	0.1	92.0	5.8	2.20
Sugarcane bagasse	41.5	11.2	3.1	74.6	20.0	5.4
Water hyacinth	32.2	17.1	5.5	69.6	23.6	6.8
Wheat straw	115.4	55.1	21.5	60.0	29.0	11.0
LSD 5%	20.2	19.5	19.8	16.2	13.1	12.1
CV(%)	25.9	49.6	78.6	22.9	47.9	77.6

Source: Kimenju et al., 2009

A study by Gibriel et al. (1996) on cultivation of oyster mushroom, evaluated three substrates namely sawdust, rice straw and water hyacinth. The result showed that the highest yield of fresh mushroom was obtained from rice straw (2448gm), sawdust was the second best organic substance tested, while water hyacinth was the third. In this study no data was given on both sawdust and water hyacinth, also found lacking is the production cycles (flushes) and information on whether entire plant of water hyacinth was used or portion of it.

From the literature reviewed above, it is observed that Kivaisi et al. (2004) used water hyacinth shoots to evaluate the performance of *Pleurotus flabellatus* but not oyster mushroom. Kimenju et al. (2009) compared 10 substrates including water hyacinth and sawdust on their suitability for oyster mushroom production while Gilbriel et al. (1996) compared 3 substrates which also included water hyacinth. None of the authors clarified whether the entire plant was used or just a portion of it. McGrath, 2003 reported that oyster mushroom can be grown using water hyacinth but provided little information.The author did not include the number of flushes obtained, standard substrate used and never mentioned the portion of water hyacinth which was used.

As per these studies, it is clear that all the authors were interested in using water hyacinth for mushroom production. Other authors have concluded that water hyacinth can be used as a substrate for oyster mushroom production. Some studies have focused on different type of mushrooms while others have done comparisons based on performance of mushrooms using water hyacinth. This aquatic plant is available in abundance locally from lakes and rivers especially from Lake Victoria where it’s seen as menace and can be obtained freely to spur mushroom industry.None of the authors attempted to use water hyacinth as possible replacement to bagasse. The current study has addressed the issue of replacement in Vihiga County.

2.4.5 Water hyacinth mixed with sawdust as substrate for bagasse on production of oyster mushroom.

Sstudies have been conducted whereby substrates are mixed in varied ratios for the purpose of producing oyster mushroom. The consideration was based on which substrate is available locally in abundance.

Nageswaran et al.(2003), in their study based on evaluation of water hyacinth and paddy straw waste for culture of oyster mushroom in India, used water hyacinth as a supplement. The plant was evaluated at 25%, 50% and 75% levels with paddy straw. The result showed that while harvesting mushroom from water hyacinth and paddy straw at a ratio of 50%:50%, it took 14 days to harvest first flush and realized a total of 7 flushes during the production cycle (Table 2.4.5a). The calculated biological efficiency was 73%. They concluded that mixing water hyacinth and paddy straw at a ratio of 50% for each, constitute a suitable substrate for early harvests to other substrates.

Table 2.4.5a: Growth and yield of oyster mushroom with different ratios of water hyacinth and Paddy straw.

Substrate %)		Days until 1^{st} harvest	Number of Times harvested	Yield/Kg Substrate (g)	Size of individual Mushroom(cm^2)	Individual Mushroom wt(g)	BE (%)
Water hyacinth	Paddy Straw						
100	0	13	8.0	182	28.3	4.6	65
0	100	17	6.5	231	33.1	3.7	69
75	25	16	6.0	154	32.4	4.8	52
50	50	14	7.5	225	37.6	5.5	73
25	75	16	6.5	276	36.9	5.0	85
C.D at 5%		0.99	NS	74	NS	NS	NS

Source: Nageswaran et al., 2003

C.D=Critical Difference

Bandopadhyay (2013) evaluated the effect of supplementing rice straw with water hyacinth on the yield and nutritional qualities of oyster mushroom. The study focused on three mushroom species namely *Pleurotus florida*,*P.citropileatus* and *P.pulmonarious.* The objective of the study was to determine the effect of the weed on the biological yield as well as on nutritional qualities of the mushrooms. The yield obtained from rice straw mixed with water hyacinth at ratio of 1:1 was high compared to when the substrates were used alone (Table 2.4.5b).The study concluded that there were no significant differences due to supplementation of rice straw with water hyacinth.

Table 2.4.5b.Yield performances of oyster mushroom cultivated at their respective optimal temperature regimes on different combinations of Rice and Water hyacinth.

Oyster mushroom	Substrate 1kg,dws	Yield*(g fresh weight mushroom/kg Dws)			Total yield (g/Kg Dws)
		1st flush	2nd flush	3rd flush	
	RS	589.3	514.6	203.5	1307.4
P.florida	WH	604.6	325.3	177.3	1107.2
14-20C	RS+WH(1:1)	761.6**	511.0	249.3	1521.9
	RS+WH(1:2)	561.8	450.0	231.0	1242.8
	RS+WH(2:1)	545	525.0	244.0	1314.0
LSD at 5%		121.1	79.4	43.0	243.5
P.citrinopileatus	RS	608.7	530.5	727.5	1611.7
(24-30C)	WH	614.7	495.7	337.0	1447.4
	RS+WH(1:1)	725.1**	504.5	478.8	1708.4
	RS+WH(1:2)	631.3	396.7	202.6	1230.6
	RS+WH(2:1)	575.0	499.0	309	1383
LSD at 5%		60.0	24.6	77	161.7
P.pulmonarius	RS	589.8	450.2	236	1276
(20-26C)	WH	615.4	336.7	176.8	1128.9
	RS+WH(1:1)	684.9**	561.2	278.8	1524.9
	RS+WH(1:2)	598.8	457.5	225.2	1281.5
	RS+WH(2:1)	577	375	288.5	1200.5
LSD at 5%		50.6	76.3	39.7	166.6

Dws=dry weight of substrate, RS=Rice straw, WH=Water hyacinth *Results are mean ± standard deviation, ** Results are significantly different ($P<0.05$)

Source: Bandopadhyay, 2013

Naresh et al.(2013) studied the production of white button mushrooms using water hyacinth as a substrate in various seasons (Summer, rainy and winter).The aim was to test aquatic plant as a substitute to Paddy straw(Rice) for the cultivation of *Agaricus bisporus* mushrooms and considered only two flushes (Table 2.4.5c).The maximum yield was obtained was from rainy season (0.87kg) and minimum was from summer (0.76kg).The result proved that water hyacinth was a viable substrate for white button mushroom cultivation. It was concluded that water hyacinth is a good substrate for the production of white buttons

Table2.4.5c.Time taken for pinhead appearance and yield of white button mushrooms using water hyacinth substrate.

S.No	Month	Season	Time taken for pinhead appearance(Days)	Production(Kgs) 1st flush	Production(Kgs) 2nd flush	Total (Kgs)
1	Jun-09	Summer	44	0.53	0.31	0.84
2	Aug-09	Rainy	43	0.55	0.32	0.87
3	Nov-09	Post monsoon	37	0.50	0.30	0.80
4	Jan-10	Winter	38	0.52	0.31	0.83
5	May-10	Summer	40	0.54	0.33	0.87
6	Aug-10	Rainy	38	0.53	0.32	0.85
7	Nov-10	Post monsoon	36	0.50	0.29	0.79
8	Jan-11	Winter	42	0.54	0.27	0.81
9	May-11	Summer	39	0.50	0.26	0.76
10	Aug-11	Rainy	37	0.53	0.33	0.86
11	Nov-11	Post monsoon	38	0.48	0.28	0.76
		Minimum	36	0.48	0.26	0.76
		Maximum	44	0.55	0.33	0.87

Source: Naresh et al., 2013

Kholoud et al. (2014) used date palm leaves with other agro wastes which included wheat straw (WS), sawdust (SD) and boobialla leaves (BL) to grow oyster mushroom in the Kingdom of Saudi Arabia (KSA). The objective of the research was to study the efficiency of cultivating oyster mushroom on date palm wastes (Leaves) mixed with other agricultural wastes available in KSA. The materials sawdust, boobialla leaves and wheat straw were mixed with date palm leaves at different ratios. Date palm leaves was mixed with wheat straw at the ratio of 25% and 75% respectively. The yields obtained from this combination was the best compared to the other mixes. The mixture also gave the best results for other parameters which were investigated.

Shah et al. (2004) conducted a comparative study on cultivation and yield performance of oyster mushroom in Pakistan (Table 2.4.5d).The objective was to investigate the cultivation of oyster mushroom on different substrates (sawdust, wheat straw and leaves). The mixing ratios were: sawdust and wheat straw(50%:50%),sawdust alone(100%),sawdust and leaves(75%:25%), wheat straw alone(100%),wheat straw and leaves(50%:50%) finally leaves alone(100%). The maximum yield of 648.5g was obtained from sawdust, therefore it was recommended for oyster mushroom production.

Table 2.4.5d.Biological efficiency, weight and average yield of different substrates.

Substrate	Weight of each substrate(g)	Average yield in 3 flushes(g)	Biological efficiency (%)
Sawdust+wheat straw	1000	435.9	43.59
Sawdust+leaves	1000	620.9	62.09
Sawdust	1000	646.9	64.69
wheat straw+leaves	1000	433.9	57.85
wheat straw	750	447.2	44.72
Leaves	1000	210.6	21.05

Source: Shah et al., 2004

As can be seen from the literature reviewed, different authors have focused on evaluating the performance of mushrooms using mixed substrates. Their reports indicate that when substrates are mixed, they enhance mushroom production. The studies by Nageswaran et al. (2003) and Bandopadhyay (2013) looked at the use of water hyacinth as a supplement to rice straw at a ratio of 50%:50% and 1:1 respectively for the production of oyster mushroom. In their studies, water hyacinth is considered as a supplement to rice without explaining the rationale. Providing an explanation is important because the mixture (substrates) have been used in equal ratios. Other researchers studied various substrates which have been mixed at varied ratios but dwelt on different aspects. Neresh et al.(2013) reported the use of water hyacinth mixed with rice straw for white button mushroom production while Kholoud et al.(2014) dwelt on the use of date palm leaves mixed with other agro wastes (WS, SD and BL) at ratio of 25%:&75%, for oyster mushroom production. The study by Shah et al. (2004) compared varied ratios (25%, 75%, and

100%) of sawdust, wheat straw and leaves as substrates for oyster mushroom production. It is not clear which plants produced the leaves used in this experiment.

From the works of these authors, it is evident that all of them were interested in using mixed substrates for mushroom production. They explored water hyacinth mixed with paddy straw, date palm leaves mixed with sawdust and wheat straw mixed with sawdust. No study has attempted to use water hyacinth mixed with sawdust as a substitute to bagasse for the production of oyster mushroom. Consequently oyster mushroom production using this mixture is unknown

2.4.6 Water hyacinth alone and when mixed with sawdust on economic profit of oyster mushroom

Dung et al. (2012) indicated that mushroom production is a lucrative business that can be adopted by ordinary farmers/growers who show commitment to the art.Kibera (1996) describes any activity primarily organized and directed toward profit making as a business. Jack (2009), states that without profit the business will not survive in the long run. Obaidullah (2013) has shown that profit is the firm's total revenues less its total cost. Studies have shown that mushroom business is a viable enterprise which creates employment to most of the rural people and generates huge incomes among other economic benefits (Kivaisi, 2007; Prophant, 2005; Quimio, 2002). Mushroom business has been studied in other countries as discussed below.

Dinghaun and Xiaoyong (1978) reported that in China, mushroom production is viewed as business often referred to as mushroom business. The story of the mushroom economy is in line with the development of macro policy. When the Household Responsibility

System (HRS), was started in 1978, collective communes were dismantled and agricultural land was distributed to individual households.When the HRS was initiated in 1978, mushroom production in China was only 60,000 tons. Soon after individual farmers got the right to decide what to produce for themselves, the mushroom industry was booming.

A study conducted by Ram et al. (2010) on benefit-cost analysis and marketing of mushroom in Haryana, India, focused on three categories of farms: Small (Up to 120), Medium (120-240) and large (Above 240) farmers. The results revealed that as the farm size increased, income generation capacity of the mushroom growers also went up. Consequently, the large mushroom growers earned more profit than small and medium growers (Table 2.4.6a). The average mushroom production across small, medium and large growers was 2639kg, 6978kg and 21910kg respectively. The average gross returns ranged between Rs88202 and 735100, while the benefit- Cost ratio (BCR) was 1.61(Small farm), 1.78(Medium) and 1.83(Large). The substrate used by farmers was mainly wheat straw on production of button mushroom type, commonly grown in India.

Table 2.4.6a: Cost and returns from mushroom production on different categories of farms

Particulars	Categories of farms			
	Small	Medium	Large	Average
Total variable cost(Rs)	33689	78731	284440	132287
Total production cost(Rs)	54683	130170	401308	195387
Mushroom production(Kg)	2639	6978	21910	10509
Average selling price(Rs/Kg)	33.40	33.15	33.55	33.37
Gross returns(Rs)	88202	231400	735100	351567
Net returns(Rs)	33519	101230	333792	156180
Returns over variable costs(Rs)	54513	152669	450660	219281
Benefit-Cost Ratio(BCR)	1.61	1.78	1.83	1.74
Cost of production(Rs/Kg)	20.72	18.65	18.32	19.23
Break-even point of output(Kg)	1017	2352	5682	3017
Net returns(Rs/Kg)	12.70	14.51	15.23	14.15

Source: Ram et al., 2010

The economy of Thailand has been boosted by mushroom business (Mushworld, 2004). The type of mushroom grown in Thailand is mainly coprinus mushroom using rice straw as a substrate which is readily available locally in large quantities. The mushroom can be grown easily both in indoor and outdoor conditions and on average 70% of the rice farmers cultivate coprinus mushrooms from rice straw which they already have. Comparison done between income from rice and mushroom indicates that a coprinus mushroom brings them more money than rice. Inspired by large income from mushroom growing, the Thailand government encouraged poor rural people to grow mushrooms because it provides quick returns for investment. The coprinus mushroom cultivation takes just three weeks to yield returns to the farmers.

Prophant (2005) analyzed the benefit and cost of coprinus mushroom production in Thailand grown on rice straw (Table 2.4.6b). The yield obtained was 200kg of mushroom which gave a gross revenue of TH8000 (USD 206.19) and a net profit of TH5570(USD143.56).The production period for coprinus mushroom is quite short and lasts only on an average of one month. Mushroom growers can grow ten to twelve (10-12) crops per year and produce huge income. The farmers have adopted both bundle and Shelf methods in an effort to grow coprinus mushroom.

Table 2.4.6b: Benefit and Cost of Coprinus mushroom production of bundle for I month.

Item	Quantity	Cost/Unit(THB)	Production cost(THB)
Rice straw	100 packets	5	500
Rope	100 pieces	2	200
Additives	17kg	40	680
Spawn	25 bottles	10	250
Fuel			200
Labor			300
Plastic sheet			200
Water & electricity			100
Total production cost			THB2430(USD62.63)
Yield (kg)			200
Price/kg (THB)			40
Total income (THB)			8000(USD206.19)
Net profit(*TRC-TVC)THB			5,570(USD143.56)

Source: Mushroom, 2005

*TR-Total Revenue,TVC-Total Variable Cost

A study by Quimio (2002) in Philippines reported a yield 95kg of mushrooms resulting into a gross profit of PHP2850 (USD570) and net profit of PHP2153.57 (USD43). The method adopted in Philippines was bed production in growing button mushroom using rice straw substrate. The contractual approach was tried in a small farming community, family-based groups. Each family had to prepare 20-40 beds per month and produced at least 95 kg fresh buttons per growing cycle of 23 days. Marketing of mushroom was done by the University of the Philippines which sponsored the project. Details of costs and revenues for button mushroom production are indicated in Table 2.4.6c.

Table 2.4.6c: Monthly financial statement

Volume of production per month	95kg
Price per kg	PHP 30
Gross income per month	PHP2850(USD 57)
Total expenses per month	PHP696.43(USD 13.93)
-Spawn(5,500ml,bottle/bed)	PHP 440(USD 8.80)
-Production overhead	PHP200(USD4)
-Depreciation of investment	PHP37.77(USD 0.37)
-Monthly pay-back of loan and interest	PHP18.66(USD 0.37)
Net income per month	PHP 2153.57(USD 43)

Source: Manual on mushroom cultivation by Peter Oei, 1991

In Zimbabwe, mushroom production has been undertaken as a means of poverty alleviation (Mushworld, 2004). Both button and oyster mushrooms are the most commonly cultivated varieties. The mushroom profitability has been compared with maize and wheat crops being the main crops (Table 2.4.6d).The results show that mushroom production in Zimbabwe is more profitable than Maize (ZWD 518,500) and Rice (ZWD 1,140,000).

Table 2.4.6d: Compared profitability of Maize, Wheat and Oyster Mushroom

	Maize	Wheat	Oyster mushroom	
Gross income(ZWD)	1,050,000	2,000,000	2,400,000	
Expected yield	3 tons/ha	5 tons/ha	240kg/20m^2	
Average price(ZWD)	350,000/Ton	400,000	10,000/Kg	
Total costs(ZWD)	531,500	860,000	697,000	
Labour	60000	25,000	Labour	50,000
Land preparation	26000	25,000	Firewood	20,000
Seed	35000	10,000	Spawn	180,000
Fertilizer/Lime	285000	580,000	Plastic bags	12,000
Insecticide	40500	45,000	Strawn	120,000
Transport	40000	55,000	Antiseptics	15,000
Levy	12000	10,000	Construction	300,000
Miscellaneous	33000	110,000		
Net income(ZWD)	518,500	1,140,000	1,703,000	

Source: Mushworld, 2004

The study by Kivaisi (2007) on oyster mushroom production from Mbeya District in Tanzania where bean trash was used as substrate for mushroom production showed that growers are making good money from mushroom business (Table 2.4.6e). The mushroom producers/growers, having been motivated by profits have formed an association known as Tanzania Mushroom Growers Association (TMGA).This is aimed at creating more wealth and taking advantage of economies of scale in their operations. The industry is constrained by economic factors, inadequate knowledge and skills of the growers, diseases and pests. These are the areas of concern that need intervention to enhance the development of the mushroom industry in Tanzania.

Table 2.4.6e: Investment and income from mushroom growing by one farmer in Mbeya

A. Capital Investment	Tshs(Euro)	
1. Building of a mushroom house(Grass roof, brick wall)	400,000	
2. Pasteurization Container	25,000	
3. Tools	26,500	
Total	451,500(268)	
B. Cost for one growing cycle		
1. Purchase of spawn(One growing cycle)	18,000	
2. Transport	5,000	
3.Purchase of bags	5,000	
4.Firewood	2,500	
5.Substrate (from own farm)	-	-
6. Labour	2,000	
Total cost for one growing cycle	32500(19.3)	
C. Mushroom Production		
100 bags(2-3kg substrates) each producing 750gm fresh mushrooms=75kg		
D.Income from mushroom sales,1kg sale@Tshs3000 x75kg)	225,000(133.5)	
E.Profit on basis of investment of one cycle: D-B	192,500(114)	
F. Payback period/Time (Growing Cycles) of capital investment :A/E	=2.3	

Source: Kivaisi, 2007

The literature reviewed above shows that mushroom production is a lucrative business worldwide(Kibera,1996;Jack,2009;Obaidullah,2013;Dinghaun&Xiaoyong,1978,Mushworld,2004;Dung et al,.2012).It was observed that Ram et al.(2010) analyzed profit of button mushroom grown on wheat straw by comparing three farms in India. The benefit cost ratios (BCR) were: 1.61(small farm), 1.78(medium) and 1.83(large).They concluded that growers from large farms made more profits. These authors have considered one benefit only namely the yield of button mushroom leaving other benefits which can be monetized. Other authors who analyzed profits from different mushrooms using different substrates did not focus on BCRs which is a critical component in determining profit margins.Kivaisi (2007) looked at profit margins of oyster mushroom using bean trash in Tanzania but considered pay back period(PBP). Prophant (2005) dwelt on profits from coprinus mushroom using rice straw while Quimio (2002) reported profits from button mushroom using rice straw.

The above studies, reveal that profits from mushroom production is emphasized regardless of the type and substrate used. It is also evident that all the authors have considered yield only as a benefit in their analysis, leaving other benefits which can be monetized. Despite these results associated with profits from mushrooms, none of the study has focused on economic profit of oyster mushroom using water hyacinth alone and when water hyacinth is mixed with sawdust. Consequently, economic profit of oyster mushroom grown on water hyacinth and when it is mixed with sawdust is unknown.

2.5 Economic evaluation technique

The economic evaluation has been described as a way of systematically analyzing all the benefits and costs associated with a project or an intervention and assessing its overall benefits (Merilyn &Ben, 2009). It involves identification, measurement and evaluation of the costs (inputs) and benefits (outputs) of the intervention (WHO, 2000). Therefore it helps to ascertain the project/intervention desirability in terms of its net contribution to the economic and social welfare of the country or economy as a whole (Sun, 2007). The intervention is economically feasible if the economic benefits (the plus) generated by the project/intervention surpass the economic costs (the minus) provoked by the intervention when weighed on a balance scale (Fig 2.1). In other words, the intervention is economically feasible if its net contribution to social welfare is positive (Sun, 2007). This is the principle of an economic analysis whereby the net contribution to social welfare of people is positive.

Fig2.1: Comparison between benefits and costs of an intervention.

Source: Sun, 2007

There are several methods or techniques used in economic evaluation of a project or an intervention. However, the main three techniques known are :

i Benefit-Cost Analysis (BCA)

ii Cost-Effectiveness Analysis (CEA)

iii Cost-Utility Analysis (CUA)

The Benefit-Cost Analysis (BCA) has been chosen or adopted as the economic evaluation criteria in this study. Benefit-Cost Analysis is a technique of evaluating a project or investment by comparing the economic benefits with the economic costs of the activity (Bryce, 2008).BCA begins with a problem to be solved and focusing on alternative strategies available. The BCA is based on the concepts of economic efficiency of an intervention/project, therefore an intervention should only be undertaken if the total benefits exceed its total costs In Benefit-Cost Analysis, all individual benefits are measured in monetary terms, meaning that all costs and consequences/outcomes are measured in the same units. Conducting ex-post BCA at the end of the study gives a better view of the intervention in an effort to make better decisions.

Nick et al.(1993) and Boardman et al.(1996), have outlined essential steps in conducting any Benefit-Cost Analysis (BCA) of the project or an intervention. Studies have shown that the two researchers have included all key areas of concern but they differ in the number of steps involved in conducting CBA. Therefore, the guide given by Nick et al. (1993) has been considered and adopted in this study.

Step 1.Definition of the project

The definition of the project includes the reallocation of resources being proposed and the population of gainers and possibly losers. This is aimed at determining the boundary and the people over which benefits and costs are to be aggregated about. For this study, Vihiga mushroom project will be the main beneficiary by focusing on the benefits (gains) of introducing water hyacinth as a substrate to promote mushroom production in Vihiga County.

Step 2.Identification of project/an intervention impacts

The relevant impacts resulting from the implementation of the project/an intervention are identified. This involves development of a comprehensive list of all resources used in the project/intervention, such as its effects on local unemployment levels and impacts on the quality of the product. For Vimpro, all possible impacts or effects on local unemployment levels, impacts on mushroom quality, yields and local prices have been considered.

Step3.Consideration of impacts with Economic Relevant.

This is aimed at addressing an economic question by isolating impacts which are economically relevant. The goal of BCA is to guide in the selection of projects which add to the total of social utility, by increasing the value of consumables. What is counted as positive impacts are listed under benefits, while those with negative impacts are listed under costs. The crucial point here is that the environmental impacts of a project/intervention count as long as it either causes at least one person in the population to become more or less happy and /or change the level of quality of output of some positive valued commodity. For Vimpro, the livelihood of the people engaged in mushroom production is threatened due to lack of bagasse substrate. Therefore this intervention of using water hyacinth could save them if the intervention is implemented as an alternative source of substrate for mushroom production.

Step 4. Physical Quantification of Relevant Impacts

This stage involves determining the physical amounts of cost and benefit flows for a project and identifying when in time they will occur. All the calculations made at this stage will be performed under varying levels of uncertainty. In some cases, it may be possible to attach probabilities to uncertain events and calculate an," expected value". The relevant physical impacts due to the introduction of water hyacinth by Vimpro for mushroom production could include: spawn run, yields, time saved in sterilization process and biological efficiency. The list is not exhaustive but all relevant impacts have been quantified.

Step 5.Monetary Valuation of Relevant Effects

In order for physical measures of impacts to be co-measurable, they must be valued in common units. The common unit in BCA is money. This is based on the currency of the country concerned , for example if it is in Kenya then the currency could be Kenya shillings (Kshs).This is merely advice of convenience rather than an implicit statement that money is all that matters.Markets often generate the relative values of all traded goods and services at relative prices. The tasks of the CBA analyst are:

(i)Predict prices for value flows extending into the future.

(ii) Correct market prices where necessary

(iii) Calculate prices (relative values in common units) where none exist.

In the case of Vimpro, the identified effects, effort has been made to attach a price in order to evaluate the benefits fairly when the water hyacinth is used as a substrate for mushroom production in the project.

Step 6. Discounting of Cost and Benefit flows

Once all relevant impacts that can be expressed in monetary amounts have been so expressed, it is necessary to convert them all into present value (PV) terms. This necessity arises from the time value of money or time preference. Therefore, all cost and benefit flows are discounted, using a discount rate. If the interest rate is, r, then the following formula given by Gerald & Marta (n.d) can be used to find the present value (PV) of an amount (Pt) received at some time,t in future.

$$PV = \frac{P_t}{(1+r)^t}$$

Where:

PV=The present value of the amount invested

P_t=The dollar or shilling value of the future amount in time,t

r=The discount rate

t=The year,or month in which Pt is realized

The expression in square brackets in the equation is known as discount factors $(1+r)^t$. The discount factors have the property that they always lie between +1 and 0.The further away in time a cost or benefit occurs, (the higher the value of t), the lower the discount factor (Nick et al.,1993). Similarly, the higher the discount rate r for a given t, the lower the discount factor since a higher discount rate means a greater preference for things now rather than later and this has been expressed graphically in Figure 2.2.

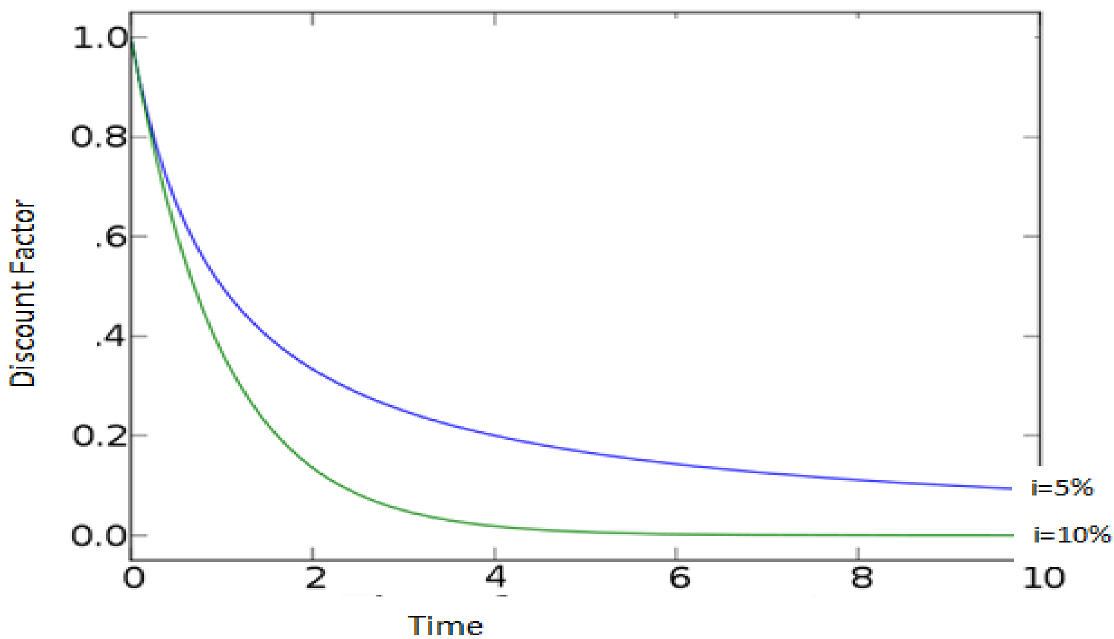


Fig 2.2:.Property of discount factors

Step7.Application of the Net Present Value Test

Since NPV depicts more on financial analysis, for economic analysis, the Economic Net Present Value denoted as ENPV has been used in this thesis. The main purpose of BCA is to help select projects/interventions which are efficient in terms of their use of resources .Therefore, the criterion applied is the Economic Present Value (ENPV) test. This is simply asking whether the sum of discounted benefits (gains) exceeds the sum of discounted costs (losses). The Economic Net Present Value (ENPV) formula is similar to

Net Present Value (NPV), but the items in the formula are defined differently (Sun, 2007; Gerald & Marta, n.d). The social benefit and social cost of the project that are relevant, uses social discount rate of 10% per year. The formula for calculating NPV is given below:

$$NPV = \sum_{t=1}^{T} \frac{\left(Benefit_t - Cost_t\right)}{(1+r)^t}$$

Where:

NPV=Net Present Value
t=Time
r=Discount rate

Step 8.Sensitivity Analysis

The ENPV described above focuses on the relative efficiency of the project or intervention, given the data input to the calculations. If the data changes, then the result of ENPV test will change too. This happens when values of certain key parameters are changed. The parameters may include:

(i) The discount rate

(ii) Physical quantities and qualities of inputs

(iii) Shadow prices of these inputs

(iv) Project lifespan

The intention is to discover to which parameters the ENPV outcome is most sensitive, for instance, how much do labour costs need to rise before ENPV becomes negative? Once the most sensitive parameters have been identified, then forecasting effort can be directed to these parameters to try to improve them and where possible, more effort can be made while the project is underway to manage them carefully. In mushroom production, key parameters include labour, spawn and growing environmental factors.

2.5.1 Benefit-Cost Measures

The BCA measures have been outlined by Gerald &Marta (n.d), as Net Present Value (NPV) and Benefit-Cost Ratio (BCR).

(i) **Net Present Value (NPV)**

The Net present value is the current value of all project net benefits. The net benefits are simply the sum of benefits minus costs as shown in the formula below. If the project or intervention has a NPV greater than zero (NPV>0), then it appears to be a good candidate for implementation. It is recommended that the projects with negative NPVs should be discarded while those with positive NPVs be undertaken.

$$NPV = \sum_{t=1}^{T} \frac{\left(Benefit_t - Cost_t\right)}{(1+r)^t}$$

Where:

NPV=Net Present value

t=time

r=Discount rate

(ii) Benefit-Cost Ratio (BCR)

The Benefit-Cost Ratio (BCR) is calculated as the NPV of benefits divided by the NPV of costs as indicated by the following formula:

$$BCR = \frac{\sum_{t=1}^{T} \frac{B_t}{(1+r)^t}}{\sum_{t=1}^{T} \frac{C_t}{(1+r)^t}}$$

Where:

BCR=Benefit- cost ratio

B=Benefit in time,t

C=Cost in time,t

According to Gerald &Marta (n.d), If the BCR exceeds one (BCR>1), then the project or intervention might be a good candidate for acceptance.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

The chapter provides detail information on key components of research study. Therefore it covers research design which was used, substrate collection and preparation, study area, data types, collection method, data analysis and presentation.

3.2 Research Design

The Completely Randomized Design (CRD) was used in this study. Kombo and Tromp (2006) indicate that subjects (treatments) in this design are randomly assigned to the experiment or to a control. Water hyacinth, water hyacinth mixed with sawdust and bagasse were considered as treatments whose effects on production of oyster mushroom were evaluated. The experiment was conducted in the year 2012-13.

3.3 Area of Study

The study was conducted at Vihiga Mushroom Project which is located in Vihiga County whose headquarter is in Mbale in the Western Region of Kenya. The county borders Nandi County to the East, Kisumu County to the South, Siaya County to the West and Kakamega County to the North (Appendix XI).Vihiga County has five constituencies: Luanda, Emuhaya, Hamisi, Sabatia and Vihiga while it has four sub-counties namely Emuhaya with an area of 173.5km^2, Hamisi (156.4km^2) Sabatia (110.9km^2) and Vihiga (90.2km^2).It has a population of 612,000 (KNBS, 2010) and is inhabited predominantly by the Luhaya. The elevation of Vihiga is estimated at 1173 metres above sea level. Latitude:-3^{o}40'0''Longititude:38^{o}38'0''.The major economic activities that drive the economy of Vihiga County include cottage industries, subsistence farming, tea farming, horticulture, livestock farming, wholesale and retail trade, quarrying , mining and mushroom production. The Vihiga mushroom project is the one that drives mushroom business in this county. The project has also established a centre at Manyatta for most of their economic activities and innovations with a coordinating office at Mbale town, which is about 4km away from this Centre. The project was started in 2002 as a Community-Based Organization (CBO) and registered in 2003. Currently, the organization has formed a Co-operative Society called HAMUSAVI Mushroom Growers Co-operative Society Ltd which was registered in 2009 with initial membership of 2600 (Silingi,2011).Apart from Mushroom products the Co-operative handles other products. The Vimpro has been in existence for more than ten years and engages in mushroom growing activities using various organic materials (substrates) for mushroom production.

3.4 Substrates collection, preparation, spawning and harvesting

Water hyacinth was harvested from Lake Victoria in Kisumu County (Plate 3.1). The roots were removed and the rest of the parts were dried in the sun for one week (Plate 3.2).The dried materials were chopped into approximately 4-6cm long segments. The dried sawdust was collected from lumbering sites within Vihiga and bagasse was obtained from Kibos Sugar Company Limited in Kisumu. Water hyacinth and sawdust were mixed at a ratio of 1:1. The three treatments (substrates) were sprinkled with water for 10-15 minutes to allow for moisture adsorption and squeezing method was used to determine the moisture content.

The substrates were weighed in (1000g) units and packed into heat resistant polythylene bags measuring 15x9 inches. For each treatment (substrate) 60 bags were made. The open end of the bag was made into neck prepared by using heat resistant pipe whose diameter was 2 cm and covered with a cotton plug.

The packed bags were steam pasteurized for 2 hours in 200 litre steam drum (Plate3.3). They were cooled overnight and spawned at the rate of 1.25% (Royse, 2004), the following day in disinfected room (Plate3.4). Few small holes (5-7) of about 1cm diameter were made on the bags to allow air exchange and then arranged on the shelves: 1st shelf carried 60 bags of the treatments randomly placed, 2nd shelf had 60 and the 3^{rd} shelf had 60 bags. The spawned bags were then left for colonization. The floor was kept humid by having four basins full of water on the floor. Spawn running ended when the substrates were fully colonized by mycelia and the bags were opened to light for fructification (Plate 3.5).Mushrooms were harvested when caps were fully opened by gently twisting the stalk and pulling them off the substrate. The harvested mushrooms were then weighed and sold.

All the bags for each type of substrate used were labeled from 1 to 60 and twenty bags from each treatment randomly selected were identified for collecting date aimed at addressing objective one and two of the study. The data collected from these bags comprised of spawn run in days and yield per flush. Since business is better analyzed with reasonable volumes, the yields obtained from the 60 bags and sales were subjected to economic evaluation aimed at addressing objective three of the study.

3.5 Data type and Collection method

3.5.1 Sources of data

Both primary and secondary data were collected. The researcher collected secondary data from documented production records of Vihiga Mushroom project (Vimpro), reports and journals. Primary data was collected from the experiment using data collection form which was designed for this purpose (Appendix I).The experiment was set up at Manyatta Centre which is also a production site for Vihiga Mushroom Project.

3.5.2 Data Collection Procedure

The researcher obtained an introduction letter from Maseno University which was presented to Vihiga Mushroom Project Management. The researcher made several visits to Manayatta Centre and to some mushroom groups. The visits were aimed at identifying any significant challenges in order to mitigate against them before commencement of the research. Also this approach assisted the researcher to identify suitable mushroom growing house and made necessary arrangements for setting up the experiment.

3.6 Data Analysis and Presentation

Two techniques have been employed in data analysis namely Analysis of Variance (Mugenda & Mugenda, 2003) and Benefit-Cost Analysis (Nick et al., 1993).

ANOVA was carried out to compare treatments (Substrates) for differences in their means. ANOVA is a technique for testing simultaneously whether two or more population means are significantly different. Therefore, one -way ANOVA was adopted in this analysis. In adopting the 95% confidence level, the statistics were significant if the p-value revealed fell below 0.05. The ANOVA was conducted to test hypotheses one and two of the study aimed at evaluating the effect of water hyacinth alone on production of oyster mushroom and water hyacinth when mixed with sawdust on production of oyster mushroom.

Benefit-Cost Analysis (BCA) technique was used to analyze economic profit of mushroom when water hyacinth alone was used on production of oyster mushroom and when mixed with sawdust on production of oyster mushroom (Nick et al., 1993). The Economic Net Present Value (ENPV) model was adopted. In adopting this technique , the water hyacinth alone and water hyacinth mixed with sawdust could be preferred if ENPV revealed was more than zero (ENPV>0) and EBCR more than one (EBCR>1).The BCA was conducted to test hypothesis three of the study.The presentation of the results were by use of tables, graphs and figures

3.7 Model Specifications

$$ENPV = \sum_{t=1}^{T} \frac{(B_t - C_t)}{(1+r)^t}$$

Source: Adopted from Gerald and Marta (n.d)

Where:

ENPV= Economic Net Present Value

B_t= Benefit of mushroom in time,t

C_t= Cost of mushroom in time,t

t = Time (e g t=1, starting month=3, ending month, r =Social rate of discount (10%)

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents the findings of this study based on the objectives. It has covered results of water hyacinth alone, water hyacinth mixed with sawdust, bagasse and economic profits of oyster mushroom. The results have been summarized, given meanings or interpretation and discussed in line with existing literature.

4.2 Findings of the study

The results and discussion cover the three objectives of the study: to evaluate the possible use of water hyacinth as a replacement to bagasse for production of oyster mushroom ,evaluate the possible use of water hyacinth mixed with sawdust as substitute to bagasse for production of oyster mushroom and determine the effect of water hyacinth alone and when mixed with sawdust on economic profit of oyster mushroom production.

4.2.1 Yields and means of oyster mushroom from the substrates tested

The yields from the substrates tested, water hyacinth alone, water hyacinth mixed with sawdust and bagasse which was used as a control have been summarized in Table 4.2.1 also in Fig 4.1.Their respective means have been obtained through calculation (Appendix VIII,IX& X). The results revealed that water hyacinth gave a low yield (1861g) but the yield increased drastically when water hyacinth was mixed with sawdust (4049g), but both were low compared to bagasse (4350g) which was used as standard.

Table 4.2.1: Yields and means of mushrooms (g)

	Water hyacinth(A)	Water hyacinth& Sawdust(B)	Bagasse(C)
	55	188	200
	100	225	165
	85	175	330
	70	235	155
	100	150	155
	85	180	325
	60	173	185
	65	105	245
	85	220	200
	75	305	300
	235	175	325
	115	190	150
	66	125	195
	140	155	230
	60	235	160
	65	328	120
	90	230	180
	75	250	85
	105	110	275
	130	295	370
Total	**1861**	**4049**	**4350**
Mean/Bag	**93.05**	**202.5**	**217.5**

Source: Research Data, 2013

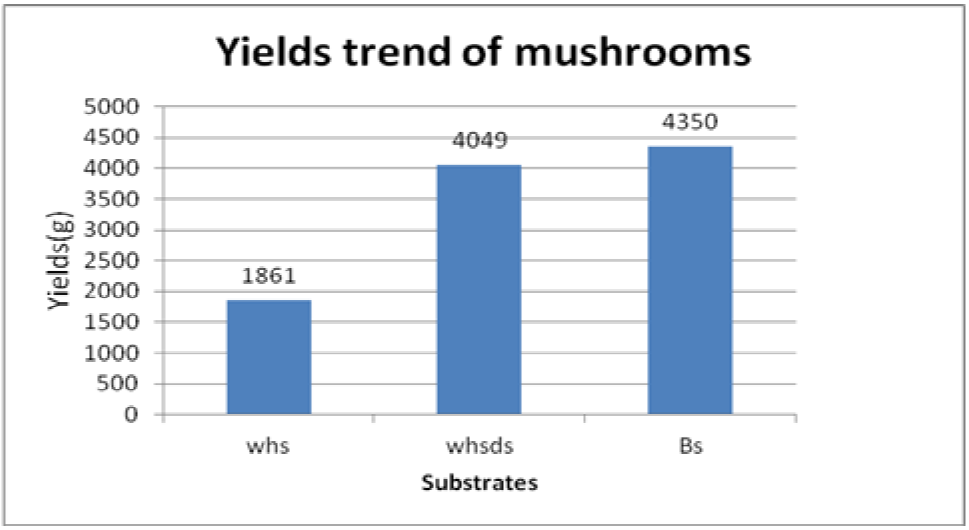


Fig 4.1: Performance trend of various substrates

Key:

Whs-Water hyacinth substrate, Whsds-Water hyacinth and sawdust substrate, Bs-Bagasse substrate

4.3 Tests of hypotheses based on Analysis of Variance (ANOVA)

In this study, the main objective was to conduct economic evaluation of water hyacinth and sawdust as alternative substrates for oyster mushroom production in Vihiga County. The study had three hypotheses, which are discussed in the sections that follow. In order to analyze the results from the experiment (CRD), one-way analysis of variance (ANOVA) technique was adopted.

4.3.1 Water hyacinth substrate for production of oyster mushroom

The first objective was to evaluate the possible use of water hyacinth as a replacement to bagasse for production of oyster mushroom in Vihiga County.This objective was realized by using yields obtained from mushroom when grown on water hyacinth alone and bagasse substrates for comparison. A hypothesis was thus stated:

H_oi: There is no significant difference between water hyacinth alone and bagasse on production of oyster mushroom.The null hypothesis is that the means are the same: H_oi: $\mu_A=\mu_C$(all treatment means are the same), and the alternative hypothesis is that the means are not the same, $H_{ai:}\mu_A\neq\mu_C$

A one-way ANOVA was conducted in order to determine if the means were significantly different with regard to the respective variables. A hypothesis can be supported if the difference in the means were significant and rejected if the difference in the means between the groups were not significant. An alpha level of 0.05 was used for all ANOVA analyses. The results are shown in ANOVA table (Table 4.3.1).

Table 4.3.1: Analysis of variance of mushroom yields using water hyacinth

Source	DF	SS	MS	F- cal.	F-tab
Between substrates	1	155081.74	155081.74	39.11	4.098
Within substrates	38	150688.24	3965.48		
Total	39	305769.97			

F-cal=Calculated, F-tab=Tabulated, using α of 0.05, ($F_{(1,38)}$ =4.098

Df-Degree of freedom, SS-Sum of squares, MS-Mean square

Source: Generated data, 2013

The findings from a one way ANOVA Table 4.3.1 showed that the effect of water hyacinth on production of oyster mushroom was statistically significant ($F_{(1,38)}$=4.098:P<0.05). The mean squares between treatments (Substrates) and within Substrates are: MS_B=155081.73 and MS_W=3965.48.Since the test statistic (F=39.11) is much larger than Fisher result (F1, 38=4.098) null hypothesis was rejected. This implies that there was a significant difference in mean yield when using water hyacinth compared to bagasse (Standard) on production of oyster mushroom and P is below 0.05(P<0.05).This is a strong evidence against the null hypothesis which stated that all treatments means were equal (H_oi:$\mu_A=\mu_C$)

Therefore the study has concluded that the two means are significantly different meaning water hyacinth cannot replace bagasse. Further test was conducted on the variability using Fisher's technique as indicated below.

Fisher's Least Significant Difference (LSD) method was also conducted to analyze the mean variances at 5% significance level between the treatments (Lynne&Herve, 2010). The LSD variability was 81.6g at 5 %(LSD.05). The mean yield from oyster mushroom cultivated on water hyacinth was 93.05g per bag while on bagasse was 217.5g giving a difference of 124.45g (217.5-93.1g). Based on LSD (0.05), the results showed that there was significant difference between water hyacinth and bagasse (124.45>81.6).Therefore the null hypothesis was further rejected, indicating significant difference in mean yield of oyster mushroom grown on water hyacinth and bagasse. These findings mean that water hyacinth cannot replace bagasse as a substrate for oyster mushroom production.

The findings of this study are in agreement with Kimenju et al. (2009) who reported that organic substrates were significantly different in suitability for oyster mushroom. However, the findings contradict the report of Kivaisi et al. (2004) who reported a high yield when water hyacinth shoots were used on production of oyster mushroom. The current study differs with these authors because it addresses replacement of the standard (Bagasse) or developing another standard for oyster mushroom.

4.3.2 Water hyacinth mixed with Sawdust in production of oyster mushroom

The second objective was to evaluate the possible use of water hyacinth mixed with sawdust as a substitute to bagasse for production of oyster mushroom in Vihiga County The hypothesis statement for this objective was:

$H_o$ii: There is no significant difference between water hyacinth mixed with sawdust and bagasse on production of oyster mushroom.

The ANOVA method was conducted to test this hypothesis. The yield of oyster mushrooms cultivated on water hyacinth mixed with sawdust and bagasse were used. Sawdust was used in the experiment to supplement water hyacinth at a ratio of one to one (1:1). Bagasse was used as a control (Standard) in this experiment for comparison purpose. The ANOVA results are indicated in Table 4.3.2.

Table 4.3.2: ANOVA of mushroom yield using Water hyacinth mixed with Sawdust & Bagasse

Source	DF	SS	MS	F- cal.	F-tab
Between substrates	1	2603.87	2603.87	0.51	4.08
Within substrates	38	192211.95	5058.21		
Total	39	194815.83			

F-cal=Calculated, tab=Tabulated $_{(1,\ 38)}$ =4.08,

The findings from a one way ANOVA Table 4.3.2 showed that the effect of water hyacinth mixed with sawdust on production of oyster mushroom was statistically insignificant, test statistic was 0.51,(P>0.05). The mean squares between and within substrates (MS_B=2603.87;MS_W=5058.21) meaning there is large variability that is not significant. These results confirm the proposition that there is no variability between the substrates. The hypothesis that there is no significant difference between water hyacinth mixed with sawdust and bagasse on production of oyster mushroom has been confirmed. The findings imply that water hyacinth mixed with sawdust can be a potential substitute to bagasse, therefore providing a solution to the problem facing Vihiga Mushroom Project in Vihiga County. Therefore, it can be concluded that water hyacinth mixed with sawdust can be a perfect substitute to bagasse in production of oyster mushroom.

This result is in agreement with the findings of Nageswaran et al.(2003) and Bandopadhyay (2013) who reported an increase in yields of oyster mushroom when water hyacinth was mixed with paddy straw at a ratio of 1:1.This implies that if water hyacinth is mixed with any proven substrate, the yield of oyster mushroom will be better.

Although the current study is consistent with the past study on performance improvement, the author did not address water hyacinth in combination with sawdust on production of oyster mushroom instead addressed water hyacinth mixed with paddy straw. Therefore, the current study has addressed this and is believed to be a better option to Vimpro's problem.

4.4 Test of hypothesis based on Benefit-Cost Analysis (BCA)

The economic evaluation was done for the three substrates based on the yields of mushroom and spent mushroom substrate (SMS) obtained when they were used as substrates for oyster mushroom production.

4.4.1 Yields of oyster mushroom

The total yield of mushrooms obtained when grown on water hyacinth alone, water hyacinth mixed with sawdust and bagasse are indicated in Table 4.4.1. The yield from 60 bags was considered in this evaluation since business thrives better on economies of scale (large quantities) aimed at cost reduction and increased profit margins.

Table 4.4.1: Total yield of mushrooms

Substrate	20 bags	40 bags	Total
Water hyacinth(Gms)	1861	9879	11740
Water hyacinth&Sawdust(Gms)	4049	17471	21520
Bagasse (Gms)	4350	18870	23220

Source: Research Data, 2013

4.4.2 Economic profits analysis of oyster mushroom production

Objective three of the study was to determine the effect of water hyacinth alone and when mixed with sawdust on economic profit of oyster mushroom production in Vihiga County. The hypothesis statement for this objective was:

$H_o$iii: There is no significant difference in using water hyacinth alone and when mixed with sawdust on economic profit of oyster mushroom.

The benefits and costs of oyster mushroom production were analyzed when water hyacinth was mixed with sawdust substrate. Also analysis of water hyacinth substrate used alone as substrate was conducted. Benefit-Cost Analysis (BCA) technique was adopted in evaluating economic profits for the interventions.

In this case, ex-post BCA was conducted at the end of the study. Two measures of benefits and costs were used: Net Present Value (NPV) and Benefit-Cost Ratio (BCR). The measures have been chosen as the economic evaluation criteria in this thesis and denoted by ENPV and EBCR.If the ENPV exceeds zero (ENPV>0), then the project/intervention is a good candidate for implementation or profitable, if the EBCR exceeds one (EBCR>1), then the project/intervention is a good candidate for acceptance (Gerald&Marta, n.d).

Present values formula:

$PV=P_t/(1+r)^t$

Where:

Pv=The present value of the amount invested(Capital)

P_t =The Shilling(Dollar) value of the future amount in time,t

r=Discount rate

t=The year in which P_t is realized

(i) The present value of the benefits are:

Benefits=Pt/ $(1+r)^t$

(ii) The present value of the costs are:

Costs= Pt/ $(1+r)^t$

(iii) Economic Net Present Value (ENPV) formula:

$$NPV = \sum_{t=1}^{T} \frac{\left(Benefit_t - Cost_t\right)}{(1+r)^t}$$

ENPV>0

Where:

NPV=Net Present Value

t=Time

r=Discount rate

iv) Benefit-Cost Ratio (BCR) formula:

$$BCR = \frac{\sum_{t=1}^{r} \frac{B_t}{(1+r)^t}}{\sum_{t=1}^{r} \frac{C_t}{(1+r)^t}}$$

BCR>1

Where:

BCR=Benefit and Cost Ratio

Bt=Benefit over time

Ct=Cost over time

t=time

(1+r)t=Discounting factor

4.4.2.1 Effect of water hyacinth on economic profit of oyster mushroom production

The benefits have been derived from sales of mushrooms produced and spent mushroom substrate (SMS). The spent mushroom substrate is rich in nutrients such as phosphorous, Nitrogen and potassium, therefore is a good form of organic fertilizer. Farmers were encouraged to purchase this form of fertilizer for their kitchen gardens.The costs were generated from the expenses incurred to produce mushroom, referred as cost of production. The economic indicators were Net Present Value (NPV) and Benefit-Cost

Ratio (BCR).How the revenues from sale of mushrooms and SMS were worked out is indicated below:

(i) P_m X Q_m

(ii) P_{sms} X Q_{sms}

Where:

P_m=Price of mushroom per kg

Q_m=Quantity of mushroom in kg

$P_{sms=}$Price of SMS per bag (Appendix VII)

Qsms=Quantity of SMS in bags

Table 4.4.2.1 below shows the results obtained when water hyacinth substrate was used in evaluating economic profit on production of oyster mushroom. The production cycle lasted for three months starting from October, 2012 to December 2012. This period involved preparation of the substrates (water hyacinth, water hyacinth mixed with sawdust and bagasse), inoculation, management, harvesting and finally selling. The local market consumed all the products (mushrooms) that came out of this experiment and also the spent mushroom substrate (SMS) got a market as organic fertilizer.

Table 4.4.2.1 Economic profit of oyster mushroom production using water hyacinth

Month	Production Costs		Benefits		T/Benefits (Kshs)	T/Costs (Kshs)	Net Benefits (Kshs)
	Detail	cost	Detail	value			
	Spawn	750	0	0	0	750	-750
	Transport	1000	0	0	0	1000	-1000
October	Polythene bags	60	0	0	0	60	-60
(2012)	Firewood	400	0	0	0	400	-400
	Substrate	0	0	0	0	0	0
	Labour	400.	0	0	0	400	-400
November (2012)			Yield(Kg)	11.74 11.74@300			
	Labour	200	Revenue		3522	200	3322
December	Labour	200	SMS(Bags)	60	0	0	0
(2012)			SMS(Bags)	60@30	180	200	-20
	Total		Revenue		3702	3010	692

Prices: Mushroom, Ksh300/Kg, SMS, Kshs30/Bag,

T-Total

Source: Researcher Data, 2013

Table 4.4.2.1 above shows that the benefit was kshs 3707, the cost kshs3010 and net benefit was kshs 692, when not discounted. Since there is consideration of value of money over time, ENPV and BCR have been calculated as shown below.

(i) Determination of Economic Net Present Value (ENPV)

Several steps have been followed as indicated below:

(a) The present Value (PV) formula for both benefits and costs:

$$PV = \frac{P_t}{(1+r)^t}$$

Where:

PV=Present Value

P_t= Amount of money received after sale of mushrooms and SMS

t=Months when activities were undertaken(October,November and December)

r=Discount rate(Social discount rate of 10% used)

(b) The present value of the benefits (PVB) are:

When t=0 (October,2012),t=1 (November,2012) t=2 (December,2012), Discount rate=10%

Applying the formula above:

PVB= $[0/ (1+0.10)^0] + [3522/ (1+0.10)^1] + [180/ (1+0.10)^2]$

=0+3201.8+148.8

=Kshs 3350.60

(c) The present value of the costs (PVC) are in the same corresponding months:

PVC= $[2610/ (1+0.10)^0] + [200/ (1+0.10)^1]+ [200/ (1+0.10)^2]$

=2610+181.8+165.3

=Kshs 2957.10

(d) The Economic Net Present Value (ENPV)

Applying the ENPV formula:

$$\text{ENPV} = \sum_{t=1}^{T} \frac{(B_t - C_t)}{(1+r)^t}$$

ENPV=Discounted total benefits minus discounted total costs (Nick et al., 1993)

=3350.6-2957.10

=**kshs 393.50**

(ii)Determination of Economic Benefit-Cost Ratio (EBCR)

The benefits and costs for the intervention are discounted, hence the following formula has been used.

$$\text{EBCR} = \frac{\sum_{t=1}^{T} \frac{B_t}{(1+r)^t}}{\sum_{t=1}^{T} \frac{C_t}{(1+r)^t}}$$

Discounted total benefits is kshs3350.6 and discounted total costs is kshs2957.10

Therefore:

EBCR=3350.6/2957.10

=1.13

This implies that for every one shilling invested, returns are ksh1.13 shillings.

The economic indicators, ENPV and EBCR, showed positive impact meaning if water hyacinth is adopted in producing oyster mushroom, growers are able to produce mushroom profitably and increase their income as opposed to having no production at all.

4.4.2.2 Effect of water hyacinth mixed with sawdust on economic profit of oyster mushroom

The total benefits were Kshs 6636.0,total cost,Kshs 3110 and net benefit at Kshs 3526.0.The details are shown in Table 4.4.2.2

Table 4.4.2.2.Economic profit of oyster mushroom production using water hyacinth mixed with sawdust

Month	Production Costs		Benefits		T/Benefits	T/Costs	Net Benefits
	Details	Cost	Detail	Value	(kshs)	(kshs)	(kshs)
	Spawn	750	0	0	0	750	-750
	Transport	1000	0	0	0	1000	-1000
October	Polythene bags	60	0	0	0	60	-60
(2012)	Firewood	400	0	0	0	400	-400
	Substrate	100	0	0	0	100	-100
	Labour	400.	0	0	0	400	-400
November			Yield(Kg)	21.52	0	0	0
(2012)							
	Labour	200	Revenue	21.52@300	6456.0	200	6256.0
December			SMS(Bags)	60	0	0	0
(2012)	Labour	200	Revenue	60 @30	180	200	-20
	Total				6636.0	3110	3526.0

Prices: Mushroom, Ksh300/Kg, SMS, Kshs30/Bag,

T-Total

Source: Researcher Data, 2013

(i)Determination of Economic Net Present Value (ENPV)

(a) The present value of the benefits (PVB) are:

When t=0 (October),t=1 (November) t=2 (December), Discount rate=10%

Applying the formula above:

PVB= $[0/ (1+0.10)^0] + [6456/ (1+0.10)^1]+ [180/ (1+0.10)^2]$

=0+5869.1+148.8

=Kshs 6017.9

(b) The present value of the costs (PVC) in the same corresponding months:

PVC= $[2710/ (1+0.10)^0] + [200/ (1+0.10)^1]+ [200/ (1+0.10)^2]$

=2710+181.8+165.3

=Kshs 3057.10

(c) The Economic Net Present Value (ENPV)

Applying the ENPV formula:

$$\text{ENPV} = \sum_{t=1}^{T} \frac{(B_t - C_t)}{(1+r)^t}$$

ENPV=Discounted total benefits-Discounted total costs

=6017.90-3057.10

=**Kshs 2960.8**

(ii) Determination of Economic Benefit-Cost Ratio (EBCR)

The benefits and costs for the intervention are discounted (Nick et al.,1993).Applying the formula:

$$\text{EBCR} = \frac{\sum_{t=1}^{T} \frac{B_t}{(1+r)^t}}{\sum_{t=1}^{T} \frac{C_t}{(1+r)^t}}$$

Discounted total benefits is Kshs6018.4 and discounted total is costs Kshs3056.9

Therefore:

EBCR=6017.9/3057.10

=1.97

For every one shilling invested, returns are Ksh1.97 shillings.

4.4.2.3 Effect of bagasse on economic profit of oyster mushroom production

The bagasse substrate has been used as a control or standard in evaluating water hyacinth alone and water hyacinth mixed with sawdust as alternative substrates.Any profit found less than the one obtained from using bagasse in oyster mushroom production, may not be a better alternative worth investing in. However,since this organic material is in short supply from sugar factories then any organic material which leads to profit can be considered.

The total benefits amounted to Kshs7146 when monetized while the total cost incurred to acrue this benefit was Kshs 3310, leading to a net benefit of Kshs 3836.The details of the analysis are indicated in Table 4.4.2.3 below.

Table 4.4.2.3 Economic profit of oyster mushroom production using bagasse

Month	Production Costs		Benefits		T/Benefits	T/Costs	Net Benefits
	Details	Cost	Detail	Value	(kshs)	(kshs)	(kshs)
	Spawn	750	0	0	0	750	-750
	Transport	1000	0	0	0	1000	-1000
October	Polythene bags	60	0	0	0	60	-60
(2012)	Firewood	400	0	0	0	400	-400
	Substrate	300	0	0	0	300	-400
	Labour	400.	0	0	0	400	-400
	0	0	Yield(Kg)	23.22	0	0	0
November	Labour	200	Revenue	23.22@300	6966	200	6766
(2012)							
December	0	0	SMS(Bags)	60	0	0	0
(2012)	Labour	200	Revenue	60 @30	180	200	-20
	Total				7146	3310	3836

Prices: Mushroom, Ksh300/Kg, SMS, Kshs30/Bag,

T-Total

Source: Researcher Data, 2013

(i) Determination of Economic Net Present Value (ENPV)

(a) The present value of the benefits (PVB) are:

When t=0 (October),t=1 (November) t=2 (December), Discount rate=10%

Applying the formula above:

PVB= $[0/ (1+0.10)^0] + [6966/ (1+0.10)^1]+ [180/ (1+0.10)^2]$

=0+6332.7+148.8

=Kshs 6481.5

(b) The present value of the costs (PVC) in the same corresponding months:

PVC= $[2910/ (1+0.10)^0] + [200/ (1+0.10)^1] + [200/ (1+0.10)^2]$

=2910+181.8+165.3

=Kshs 3257.10

(c) The Economic Net Present Value (ENPV)

Applying the ENPV formula:

$$\text{ENPV} = \sum_{t=1}^{T} \frac{(B_t - C_t)}{(1+r)^t}$$

ENPV=Discounted total benefits-Discounted total costs

=6481.5-3257.10

=**Kshs 3224.40**

(ii) Determination of Economic Benefit-Cost Ratio (EBCR)

The benefits and costs for the intervention are discounted (Nick et al.,1993). Applying the formula:

$$\text{EBCR} = \frac{\sum_{t=1}^{T} \frac{B_t}{(1+r)^t}}{\sum_{t=1}^{T} \frac{C_t}{(1+r)^t}}$$

Discounted total benefits is Kshs 6481.5 and discounted total is costs Kshs3257.10

Therefore:

EBCR=6481.5/3257.10

=1.99

For every one shilling invested, returns are Kshs1.99 shillings.

4.4.2.4. Summary of ENPVs and EBCRs

Table 4.4.2.4 and Figure 4.2&4.3, shows the comparison of the results from water hyacinth substrate, water hyacinth mixed with sawdust and bagasse in the production of oyster mushroom.

Table 4.4.2.4: Summary of ENPVs and EBCRs

Substrate	ENPV	EBCR
Water hyacinth	393.50	1.13
Water hyacinth&Sawdust	2960.80	1.97
Bagasse	3224.40	1.99
Acceptance level	ENPV>0	BCR>1

Source: Researcher Data, 2013

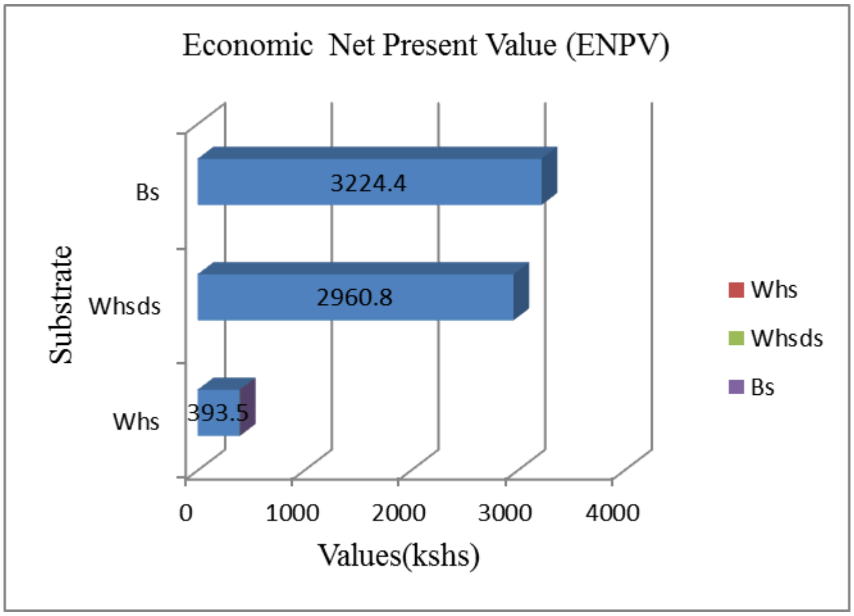
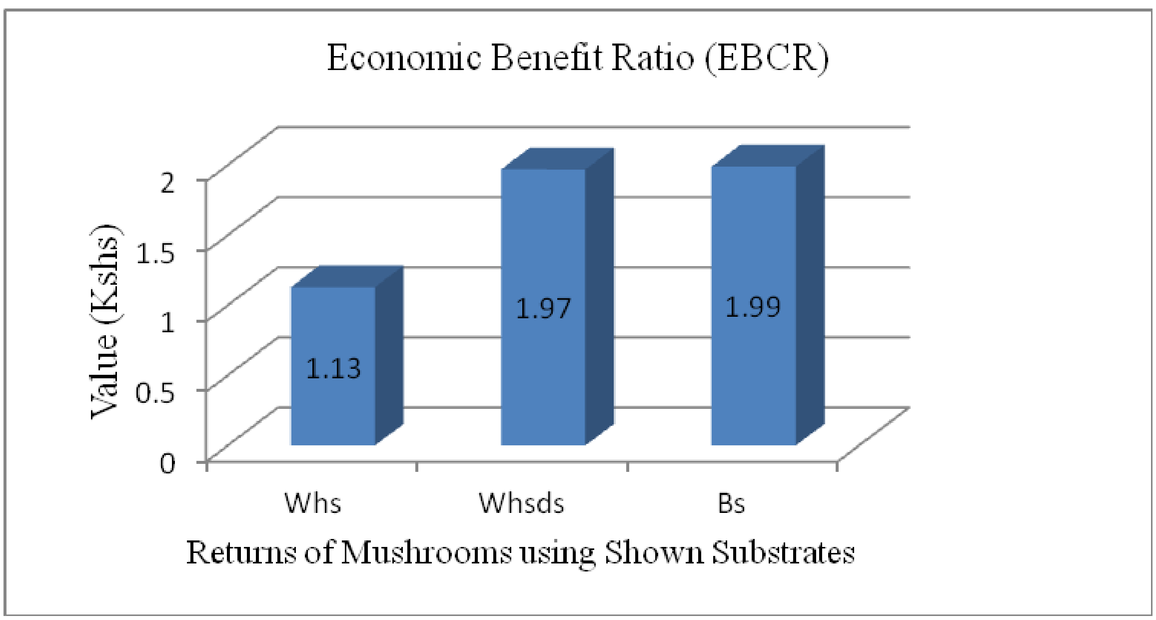


Fig 4.2:Mushroom Returns using WHS,WHSDS&BS



WHS=water hyacinth substrate, WHSDS=Water hyacinth and sawdust substrate, BS=Bagasse substrate

Fig 4.3: Returns on Investment from Mushroom using WHS, WHSDS &BS

Table table 4.4.2.4 and Figure 4.2&4.3, presents summary of economic net present values(ENPVs) and economic benefit-cost ratios(EBCRs)whereby water hyacinth alone had an ENPV of Kshs 393.50,water hyacinth mixed with sawdust was Kshs2960.80 and bagasse was Kshs3224.40 with their respective EBCRs of Kshs 1.13, Kshs 1.97 and Kshs1.99 .This means that water hyacinth substrate used alone as substrate on production of oyster gave a low economic profit but inreased substantially when water hyacinth was mixed with sawdust.

According to BCA criteria (Nick et al.,1993):If ENPV is greater than zero (ENPV>0) and EBCR is greater than one (EBCR>1) the project or intervention should be accepted. The result of ENPVs are greater than zero(393.50&2960.80) and EBCRs are more than one (1.13&1.97).Therefore, the hypothesis that there is no significant difference in using water hyacinth alone and when mixed with sawdust on economic profit of oyster mushroom was confirmed/accepted.

It was concluded that water hyacinth mixed with sawdust on the production of oyster mushroom can generate more income to mushroom producers which is the ultimate goal for undertaking mushroom production as an economic activity.

The results of ENPVs and EBCRs are consistent with the findings of Singh et al. (2005) who analyzed the benefit and cost of button mushroom grown on rice straw focusing on farm sizes and found BCR of 1.61,1.78 and 1.83 and recommended big farms on the basis of BCA anlysis criterion.

The past studies although agrees with the current study that huge profits are realized from mushrooms grown on various substrates,none has addressed benefit-cost analysis of mushrooms using water hyacinth and when water hyacinth is mixed with sawdust, which the current study sought to address. The current study has proved that oyster mushroom production using water hyacinth and when water hyacinth is mixed with sawdust can lead to increased economic profit.Therefore,expansion of the mushroom industry in Kenya is expected to be boosted by these substrates.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter focuses on the main findings presented in the thesis. The chapter covers summary of the key findings, conclusions, recommendations, limitations and suggestions for further research.

5.2 Summary of the Findings

The findings indicated that there was a significant difference in yields obtained from oyster mushroom using water hyacinth alone as a substrate .This result implies that water hyacinth is an inferior substrate compared to bagasse substrate which is considered as standard for production of oyster mushroom in Kenya.

The yield of oyster mushrooms cultivated on water hyacinth mixed with sawdust substrate did not show any significant difference between water hyacinth mixed with sawdust compared with bagasse for the production of oyster mushroom. This means that the mixture provides the best substrate for oyster muhroom production and can be a substitute for bagasse.

Further, the results on economic profit of mushroom revealed that ENPVs and EBCRs were all positives implying that the sum of discounted benefits exceeded the sum of discounted costs. This means that mushroom producers can make money using any of the two alternative substrates on oyster mushroom production in Vihiga County. However, oyster mushroom grown on water hyacinth mixed with sawdust gives a higher economic profit than water hyacinth alone.

5.3 Conclusions of the study

The first objective was to evaluate the possible use of water hyacinth as a replacement to bagasse for production of oyster mushroom in Vihiga County.Based on the results obtained, whereby the mean yields were significantly different, it can be concluded that water hyacinth alone cannot replace bagasse for production of oyster mushroom.

Objective two of the study was to evaluate the possible use of water hyacinth mixed with sawdust as a substitute to bagasse for production of oyster mushroom in Vihiga County. From the findings which showed no significant difference in yields of mushroom compared to the use of bagasse, the study concluded that water hyacinth mixed with sawdust can provide the best substitute for bagasse in production of oyster mushroom. This implies that the mixture can lead to similar performance like bagasse in the production of oyster mushroom.

The third objective was to determine the effect of water hyacinth alone and when mixed with sawdust on economic profit of oyster mushroom production in Vihiga County. Results indicated that both water hyacinth alone and when water hyacinth was mixed with sawdust resulted into profit margins. It was concluded that water hyacinth mixed with sawdust in the production of oyster mushroom can generate more income to mushroom producers which is the ultimate goal for undertaking mushroom production as an economic activity.

5.4 Recommendations of the study

Based on the findings and conclusion drawn from this study, although the results indicated that water hyacinth alone is an inferior susbtrate to bagasse, in the absence of bagasse, it can be recommended for use in the production of oyster mushrooms by Vihiga Mushroom Project in Vihiga County. This can offer a partial solution to the problem the project is facing namely lack of bagasse substrate. The water hyacinth is abundantly available locally from Lake Victoria. This plant which has been perceived as a menace for a long time could generate economic value.

The results of the study indicated good performance of oyster mushrooms using water hyacinth mixed with sawdust. Therefore, the study has recommended the use of water hyacinth mixed with sawdust as a substitute for bagasse in the production of oyster mushroom in Vihiga and to other mushroom producing areas in Kenya. This can facilitate the development of mushroom industry in the country.

The findings on economic profits of oyster mushrooms in using water hyacinth alone and when mixed with sawdust as substrates provided positive profit margins. However, the best profit margin was obtained from the use of water hyacinth mixed with sawdust. Therefore, to spur mushroom business, the study has recommended water hyacinth mixed with sawdust substrate in order to optimize mushroom economics aimed at wealth creation.

5.5 Limitations of the study

The water hyacinth by nature is a floating weed in the lakes and rivers. The area covered by water hyacinth in 2013, according to Oketch (2013) was more than area 68, 000ha in Lake Victoria alone. However, the researcher experienced difficulty occasionally in collecting it from the lake. At times, the material would be plenty and in other periods, it could be scarce due to the waves caused by storms in the lake. During the period of scarcity, accumulating the amount desired for the experiment was not easy but took time. Another challenge faced was drying the plant during the rainy season since the plant is succulent in nature. The challenges were addressed by hiring youths in Kisumu who collected the water hyacinth and dried it while further drying was done at Manyatta Centre

The inadequate mushroom production data from Vihiga Mushroom project (Vimpro), posed a challenge. The researcher wished to get mushroom production data since inception of the project in 2002, but managed to get data for two years namely 2009 and 2011. The reason given by Vimpro management was that their computers containing mushroom production reports were stolen when the office was broken into by thieves in 2011. However, some data were retrieved from a flash disk which assisted the researcher to move on with literature review. Some of the information was sought from mushroom growing groups and also individual growers who were resourceful in the provision of the information.

While BCA is a useful tool in data analysis, there are some difficulties with its application. First, it requires that the analyst assigns monetary value to all benefits and costs. There are numerous benefits and costs which are intangible and therefore difficult to value. The benefits and costs which arise in the present are known while many that arise in the future are unkown. The challenge was addressed by considering two benefits, revenues from mushroom yields and spent mushroom substrate (SMS).

5.6 Suggestions for further research

There is need to further investigate the effect of water hyacinth substrate in the production of oyster mushrooms.Past studies have shown high yields achievement whereas this study found low yields when used alone. Therefore, there is need to validate the results further.

There was a remarkable yield improvement of oyster mushroom using water hyacinth mixed with sawdust. Therefore, there is need to further investigate the performance of oyster mushroom using water hyacinth and other agricultural waste materials.

It could also be of interest to investigate the use of water hyacinth roots alone in the production of oyster mushroom although they are known to absorb metals.

The economic evaluation of mushrooms using Benefit Cost Analysis (BCA) technique showed that all ENPVs and BCRs were positives meaning that the project or decision should be implemented. However, there is need to identify sensitive parameters of BCA and carry out sensitivity analysis. For instance how much does labour need to rise before ENPV becomes negative?

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APPENDIX I

Form for data collection

Site: Manyatta   Date of spawning:________   Substrate type:___________

Bag	No. of flushes(Date)				Yields per flush(Gm)				Total yield(Gm)			
	1	2	3	4	1	2	3	4	1	2	3	4
Total												

Source: Developed by the Researcher,2012

APPENDIX II.

Projections of mushroom production per production cycle, 2012

Operational costs	First production Cycle			Second production Cycle			Third production Cycle		
	Qty	Cost / Unit	Total	Qty	Cost /Unit	Total	Qty	Cost /Unit	Total
Spawn(kg)	300	400	120000	300	400	120000	300	400	120000
Substrate(Lorry)	1	10000	10000	1	10000	10000	1	10000	10000
Spirit(Litres)	20	150	3000	20	150	3000	20	150	3000
Broiler starter(Bags)	2	3600	7200	2	3600	7200	2	3600	7200
Molasses(Jericans)	2	700	1400	2	700	1400	2	700	1400
Polythene bags(Pks)	3	500	1500	3	500	1500	3	500	1500
Polythene rolls	2	3500	7000	2	3500	7000	2	3500	7000
Lime(Pks)	1	650	650	1	650	650	1	650	650
Water(Season)	1	3000	3000	1	3000	3000	1	3000	3000
Sisal twine(Pieces)	2	200	400	2	200	400	2	200	400
Fuel(Season)	1	3000	3000	1	3000	3000	1	3000	3000
Labour(3months)	9	3000	27000	9	3000	27000	9	3000	27000
Packaging materials(Kg)	3000	5	15000	3000	5	15000	3000	5	15000
Transport to mkt(Kg)	3000	5	15000	3000	5	15000	3000	5	15000
Misc 2% on total	-	-	4283	-	-	4283	-	-	4283
	-	-	218433	-	-	218433	-	-	218433
Expected yields(Kg)	3000	-	-	3000	-	-	3000	-	-
Less spoilage 2%	60	-	-	60	-	-	60	-	-
Saleable(kg)	2940	200	588000	2940	200	588000	2940	200	588000
Gross profit	-	-	373567	-	-	373567	-	-	373567

Source: Sillingi's Production projection, 2012

APPENDIX III.

World Mushroom Production in 2002

Country	Metric Tons
China	1,244,968
United	390,000
Netherlands	280,000
France	150,000
Poland	90,000
Spain	80,000
Canada	77,000
Italy	70,000
United Kingdom	67,626
Japan	67,224
Germany	60,000
Ireland	60,000
Other	32,4675
Total	2,961,493

Source: United Nations,2002

APPENDIX IV

Estimated Annual Production of Oyster Mushroom in USA

Year	No. Growers	Annual(x1000lb)	Per Wk/Grower
1988	47	2210	904
1999	63	3729	1138
2000	68	3573	1010
2001	54	3817	1359
2002	51	4265	1608

Source: United States Department of Agriculture (USDA, 2002)

APPENDIX V

Sugarcane and Bagasse production

Country	Sugarcane(1000)	Bagasse production (1000t)	Theoretical Power Generation potential(Mwh/year)
Ethiopia	2,454	859	282,242
Kenya	4,661	1,631	536,014
Malawi	2,100	735	241,500
Sudan	5,500	1,925	632,500
Swaziland	4,500	1,575	517,500
Tanzania	2,000	700	230,000
Uganda	1,600	560	184,000
Total	22,815	7,985	2,623,756

Source: AFREPREN, 2004

APPENDIX VI

Mushroom production trend in Vimpro

Year	Production form	Quantity(Kg)
2009	Fresh Mushroom	73370
	Dried Mushroom	56
2010	Fresh Mushroom	0
	Dried Mushroom	0
2011	Fresh Mushroom	1782
	Dried Mushroom	95
2012	0	0

Source: Vimpro Annual Reports, 2009, 2011

APPENDIX VII

Selling price and cost of production per Kg of mushroom

Group/Individual	Selling price (Kshs)		Cost of Production(Kshs)	
	Fresh Mushroom	Dried Mushroom	Fresh Mushroom	Dried Mushroom
Jindinda	200	1500	65	715
Shibilinga	200	1500	65	715
Mushasha	200	1500	65	715
Buricha	200	1500	65	715
Ebwari	200	1500	65	715
Evojo	200	1500	65	715
Emutaya	200	1500	65	715
Ketenda	200	1500	65	715
Muhanda	200	1500	65	715
Individual	200	2000	100	900
Individual	200	2500	100	900
Individual	200	2600	50	650
Individual	200	2000	100	900
Mean	**200**	**1738.50**	7**1.90**	**752.70**

Price for Spent Mushroom Substrate (SMS) ,Kshs 30 per bag.

Price of fresh mushroom at Mbale township was Kshs100 per 300gms,Ksh300/kg

Source: Survey Data, 2013

APPENDIX VIII

Water hyacinth substrate on Production of oyster mushroom

Water hyacinth substrate (Bags)	Spawn run (Days)	Yields per Flush (g)			Total yield Per Bag(g)	*BE (%)
		First	Second	Third		
1	31	20	20	15	55	11.0
2	40	30	40	30	100	20.0
3	39	30	30	25	85	17.0
4	40	20	30	20	70	14.0
5	32	50	30	20	100	20.0
6	34	20	30	35	85	17.0
7	40	15	20	25	60	12.0
8	37	20	30	15	65	13.0
9	36	30	30	25	85	17.0
10	38	25	30	20	75	15.0
11	40	100	70	65	235	47.0
12	37	50	40	25	115	23.0
13	38	25	20	21	66	13.2
14	34	80	50	10	140	28.0
15	36	25	20	15	60	12.0
16	38	30	15	20	65	13.0
17	37	40	30	20	90	18.0
18	39	20	35	20	75	15.0
19	35	50	30	25	105	21.0
20	40	70	40	20	130	26.0
Total	-	750	640	471	1861	-
Mean	37.0	37.5.	32.0	23.6	93.1	18.61

Source: Research Data, 2013

APPENDIX IX

Water hyacinth mixed with sawdust on production of oyster mushroom

*Water hyacinth &sawdust substrate (Bags)	Spawn run (Days)	Yields per Flush(g)			Total yield Per Bag(g)	BE (%)
		First	Second	Third		
1	35	23	65	100	188	37.6
2	40	40	125	60	225	45.0
3	40	75	25	75	175	35.0
4	32	75	100	60	235	47.0
5	40	75	50	25	150	30.0
6	41	50	100	30	180	36.0
7	41	125	23	25	173	34.6
8	40	25	50	30	105	21.0
9	37	45	75	100	220	44.0
10	36	125	100	80	305	61.0
11	35	50	25	100	175	35.0
12	30	40	100	50	190	38.0
13	35	50	50	25	125	25.0
14	33	100	25	30	155	31.0
15	40	75	100	60	235	47.0
16	41	125	123	80	328	65.6
17	34	150	50	30	230	46.0
18	34	175	50	25	250	50.0
19	34	60	25	25	110	22.0
20	32	100	125	70	295	59.0
Total	-	1583	1386	1080	4049	-
Mean	36.5	79.2	69.3	54	202.5	40.5

Source: Research Data, 2013

APPENDIX X

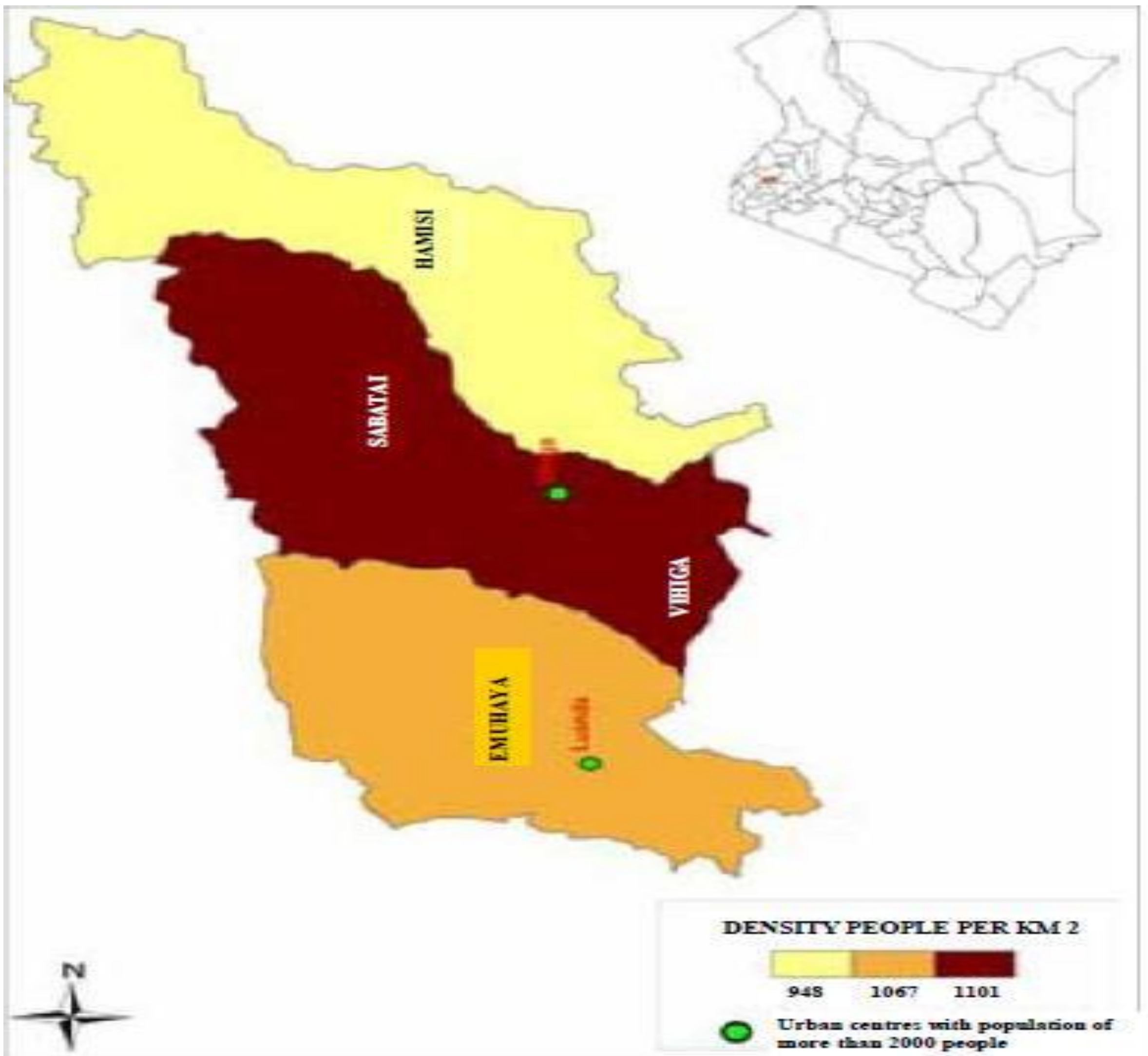
Bagasse substrate on production of oyster mushroom

Bags	Days until 1st flush	Yields per Flush in Gms(Y)			Total	BE (%)
		First	Second	Third		
1	34	50	100	50	200	40
2	37	100	25	40	165	33
3	26	130	125	75	330	66
4	37	75	50	30	155	31
5	34	50	75	30	155	31
6	37	100	125	100	325	65
7	34	25	100	60	185	37
8	37	125	50	70	245	49
9	34	100	50	50	200	40
10	34	100	125	75	300	60
11	37	150	100	75	325	65
12	34	75	50	25	150	30
13	37	100	60	35	195	39
14	37	50	100	80	230	46
15	37	100	25	35	160	32
16	34	10	50	60	120	24
17	37	125	25	30	180	36
18	43	25	30	30	85	17
19	37	125	80	70	275	55
20	42	200	100	70	370	74
Total	-	1815	1445	1090	4350	-
Mean	36	90.8	72.3	54.5	217.5	43.5

Source: Research Data, 2013

APPENDIX XI.

Map of Vihiga County, Kenya



Source: Google map

Plate 3.1.Water hyacinth harvested being collected

Plate 3.2 Drying process using sun

Plate 3.3.Pasteurization process

Plate 3.4 Spawning process

Plate 3.5 Mushrooms from growing bags placed on shelves