UTILIZATION OF WATER HYACINTH AS AN ALTERNATIVE SUBSTRATE FOR MUSHROOM FARMING: A STUDY OF VIHIGA MUSHROOM PROJECT IN WESTERN KENYA

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ABSTRACT

This study investigated the utilization of water hyacinth as an alternative substrate for mushroom farming in Vihiga Mushroom Project within Vihiga County. The water hyacinth is pretty in rivers and lakes due to its ability to double biomass rapidly and is considered as a menace on water activities in the lakes. Many strategies have been introduced such as physical removal, chemical and biological for eradication with little focus on its economic value. Mushroom farming is an agribusiness economic activity undertaken by Vimpro, currently faced with shortage of bagasse and sawdust substrates, a scenario which has contributed to production decline from 73370kg in 2009 to 1782kg by 2011. The study used exploratory research design and sampled 166 farmers using cluster sampling technique. The data was analyzed using Pearson's correlation technique. The results showed that there is enormous demand potential with 99.4% respondents willing to use water hyacinth substrate. The water hyacinth substrate alone yielded 94.2gms/ bag and recorded 202.6gms when combined with sawdust susbtrate.The gross- margin of mushroom was kshs 912/ bag, using water hyacinth substrate alone but increased to kshs3746 when combined with sawdust substrate. Based on these results, the study concluded that water hyacinth substrate offers a solution for mushroom farming in Vimpro.

1. INTRODUCTION

The water hyacinth is affecting water bodies and suppresses growth of other aquatic plants (George, 2008).Most countries have declared it as a menace which must be controlled (Phiri, 1997).Innovatively this challenge can be turned into an oppoertunity,thus utilization of water hyacinth as substrate for mushroom farming is one way(Olal e tal,2001).Some Entrepreneurs have noted this opportunity and started to utilize it in making handicrafts, briquettes and industrial cellulase (Keith&Hans-Martin,2000;James,2002;Sravani,1999).Also an attempt has been made to use it as substrate for mushroom cultivation in Thailand and Zimbabwe(Prophant, 2005; McGrath, 2003).The plant is the world's fastest growing water-borne weed with ability to double its biomass in less than two weeks (Lewis, 2002). A single plant under ideal conditions can produce 3,000 others in 50 days, and cover an area of 600 sq metres of water surface in a year (James, 2002). It has been estimated that more than 680 sq.km, equivalent to 68,000 ha in Lake Victoria is covered with water hyacinth weed (Oketch, 2013). In the countries where water hyacinth has caused havoc they have embarked on controlling or eradicating it using physical, chemical and biological techniques. The biomass from this weed can create enormous business opportunities if perceived positively especially in the mushroom industry. Currently there is a shortage of bagasse and sawdust substrates leading to a decline in mushroom production from 73370kg in 2009 to 1782kg by 2011 at Vihiga Mushroom Project in Vihiga County. Due to this shortage farmers are using various agricultural and forest wastes in an effort to grow mushrooms which are equally in short supply because the sources are scarce.

The potential mushroom production in Kenya is over 100,000 tons annually; however, it stands at 500 tons and consumption at 650 tons, an indication that the demand surpasses the supply by 150 tons (Wambua, 2004; Njagi, 2009). Unless alternative and steady source of substrate is found, the low mushroom production will certainly continue and consumption demand will only be met by importation from countries like China (Dinghaun & Xiaoyong, 1978).The quick multiplication ability, coupled with fast growth, and fast biomass accumulation, water hyacinth is a possible solution to a shortage of mushroom substrate being experienced in Western Kenya (Lewis, 2002).

The mushroom production depends largely on quantity and quality of substrate used. If the quantity is low and of poor quality, the production of mushroom is directly affected.Asubstrate is the growing medium for mushroom as soil is to plants (Hyunjong & Hyung, 2004). In recent years, Oyster mushroom has been produced using various substrates such as bagasse, sawdust, banana leaves and many other agricultural wastes, but the main substrates have been bagasse and sawdust due to their availability from both sugar and timber industries,however,the two substrates have become scarce. This is as a result of the development of cogeneration, a process of using bagasse as feedstock to produce both electricity and heat for the factories (Kerekezi, 2002).The potential for electricity generation from bagasse is high, since cogeneration equipment is almost always an integral component of sugar factory design. Estimates show that upto 16 Sub-Saharan African countries have met significant proportions of their current electricity consumption from bagasse-based cogeneration in the sugar industry (Karekezi & Kithyoma, 2005).Mauritius provides the best example of highly successful use of cogeneration, meeting over 60 per cent of its electricity generation, with over half of this coming from bagasse sourced from the sugar industry (Karekezi& Kithyoma, 2005).

In Kenya, cogeneration technology with bagasse as the primary fuel is practiced in six sugar factories in the Western part of the country. The companies include Muhoroni, Chemelil, Mumias, Nzoia, Sony and West Kenya. These companies produced an average of 1.8 million tons of bagasse per year, 60% was used as boiler fuel for steam generation and electricity production while 40% disposed off, at times at a cost (Karekezi & Kithyoma, 2005).Currently, Mumias Sugar Company is self-sufficient in electricity generation and the rest are net importers of electricity from the national grid to supplement their internal generation. The ministry of Energy has encouraged the Sugar companies to install larger and more efficient boilers to enable them fully utilize all of the bagasse they produce. Thus Mumias Sugar company became the first to apply for a license to the Energy Regulatory Commission and granted in May 2009 to co-generate 38MW, West Kenya and Kibos have done the same and permission given (Otieno,2011) This is good news to respective companies but spells doom to mushroom industry which depends on the bagasse. The study carried out by Owino (2009) on bagasse production from both Mumias and Muhoroni factories showed that a total of 1,040,000 tons of bagasse was produced from 2,750,000 tons of crushed sugarcane, giving an average of 37.8% for bagasse and cane ratio. Currently whatever is produced at Mumias sugar factory is fully consumed by cogeneration plant and occusationally imports some from other factories to sustain the cogeneration plant. Mumias Factory has been the main supplier of bagasse to Vihiga Mushroom Project (Vimpro), thus being unable to supply the same to Vimpro due to alternative use, has contributed immensely to reduced activities in mushroom farming and decline in production.

The sawdust substrate which comes from timber industry is equally in short supply. The trees from natural forests are increasingly becoming less available because of conservation, environmental and social concerns (Anyonge&Roshetho, 2004).Industrial plantations make up about 5% of the total forest area but provide 35% of the world's wood supply (FAO, 2001).Expansion of industrial plantations, however, is limited because of competition from alternative land uses and yet the demand for timber and tree products is increasing at the local, regional and International levels. In Kenya, the presidential ban on logging which was imposed in 1999 to save Kenya's forest cover contributed immensely to low sawdust production. It led to closing down of 300 sawmills, although was lifted in 2011, still sawdust substrate is not available (Anonymous, 2010; Siele, 2011). Kenya Government wants to improve the forest cover to 10% from 2 %(Gari, 2011). Another challenge in using sawdust substrate in mushroom cultivation is standardization. It is difficult to standardize sawdust substrate because it's generally obtained from residues of different types of wood and some tree species produce unsuitable sawdust substrate The agricultural wastes are based on seasonality hence not available throughout the year (Stamets, 1994; Dietzler, 1997).

One advantage of mushroom farming is that they are grown in a simple house made of grass and mud, the only major limitation is availability of good substrate. The availability of the substrate will spur oyster and button mushrooms to be commercialized in Kenya like it has happened in other countries such as China (Kimenju e tal, 2009). The survey carried out by Family Concern (2005) valued mushroom production in Kenya at kshs340 million whereby larger-scale mushroom producers account for over 95%. The imported products accounts for a significant market of 30% at the Supermarket level.

The Vihiga Mushroom Project(Vimpro) was initiated by Vihiga farmers with the help of the Ministry of Agriculture in the year 2002(FamilyConcern,2005).The district experiences scarcity of agricultural land due to high population, and majority owning less than ¼ an acre of land for farming. The government through the Ministry of Agriculture encouraged farmers to start the growing of mushrooms as an alternative to other forms of farming. The fact that commercial mushroom production could take place in very minimal area of land motivated many peasant farmers to undertake the project. With depressed bagasse substrate supply from Mumias Sugar Factory and other factories due to establishment of cogeneration plants, Vimpro has experienced depressed production. The production in 2009 of fresh mushroom was 73370kg but dropped to 1782kg in 2011 and there was no production in 2012.This shows a drastic decline in mushroom production leading to reduced economic activities for the groups affiliated to Vihiga Mushroom Project which impacts negatively in economic growth of Vihiga County. The possible solution is to introduce water hyacinth as an alternative substrate for mushroom farming currently considered as a menace and is readily available from lakes and dams particularly Lake Victoria.

RESEARCH OBJECTIVES

The overall objective of the study was to determine utilization of water hyacinth as an alternative substrate for mushroom farming in Vihiga County. Specifically the study sought to: Establish yields per flush of mushrooms from water hyacinth substrate, examine the relationship between biomass and yields per flush of mushrooms, determine gross-margins and evaluate cost-benefits of mushroom farming using water hyacinth substrate.

2. METHODOLOGY AND DATA

Exploratory research design was used in this study and helped to obtain insights into the relationships between variables and new ideas relating to research problem (Kothari, 2004; Ng'ang'a etal, 2009). Water hyacinth substrate utilization in mushroom production is relatively new and little information is available on the relationship between biomass, flushes and yields of mushroom. The area of study was Vihiga Mushroom Project which is located in Vihiga County with a population of 387 as revealed by the study, initially shown as 284 engaged in mushroom farming. The cluster random sampling technique was considered suitable for this study because the population is dispersed across a wide geographical region. Sample size of 166 was used representing 58.5% of the target population. Primary data was collected from smallholder mushroom farming groups and independent individual farmers using Questionnaires, Interview Schedule and observation (Mugenda,1999;Best&Khan,1999;Denscombe, 1999, Kombo&Tromp, 2006).The Secondary data was obtained from published and unpublished sources. The data was analyzed using Pearson's correlation technique with the help of SPSS. (O'Connor, 2011; Harper, 1991).

3. FINDINGS AND DISCUSSION

The age of the mushroom farmers was investigated in order to know which categories of farmers are actively involved in the business of mushroom farming. Table 3.1 presents frequencies and percentages based on the age of mushroom growers in Vihiga Mushroom Project (Vimpro).

Table 3.1.Age distribution

Age in years	Frequency(n)	% Frequency	Cumulative (%)
18-25	8	5.0	5.0
26-33	62	38.8	43.8
34-41	25	15.8	59.4
0ver 42	62	40.6	100.0
Total	160	100.0	

Source: Field data, 2013

According to table 3.1 above, the responses showed that 40.6% of the mushroom farmers are over 42 years who are active in mushroom farming, while young and vibrant youth between 18 and 25 years form only 5% of the mushroom farming community in Vimpro in Vihiga County. This is not a good trend given that the government has established Youth Enterprise Fund countrywide to support the youths initiate income generating activities to empower them economically and also creating own employment. Therefore there is need to investigate further as to why the youths are not interested in mushroom farming. The middle aged group between 34 and 41 years forms 38.8% of the mushroom farmers in Vimpro.This trend needs to be reversed so as to have more people involved from lower age bracket preferably between 18 and 33 years (43.8%), if the mushroom cultivation will remain as one of the major economic activity to boost economic growth of Vihiga County. The study also evaluated the willingness of farmers affiliated to Vihiga Mushroom Project to use water hyacinth as substrate. Table 3.2 below, presents frequencies of the number of farmers who were willing and unwilling to use water hyacinth if made available.

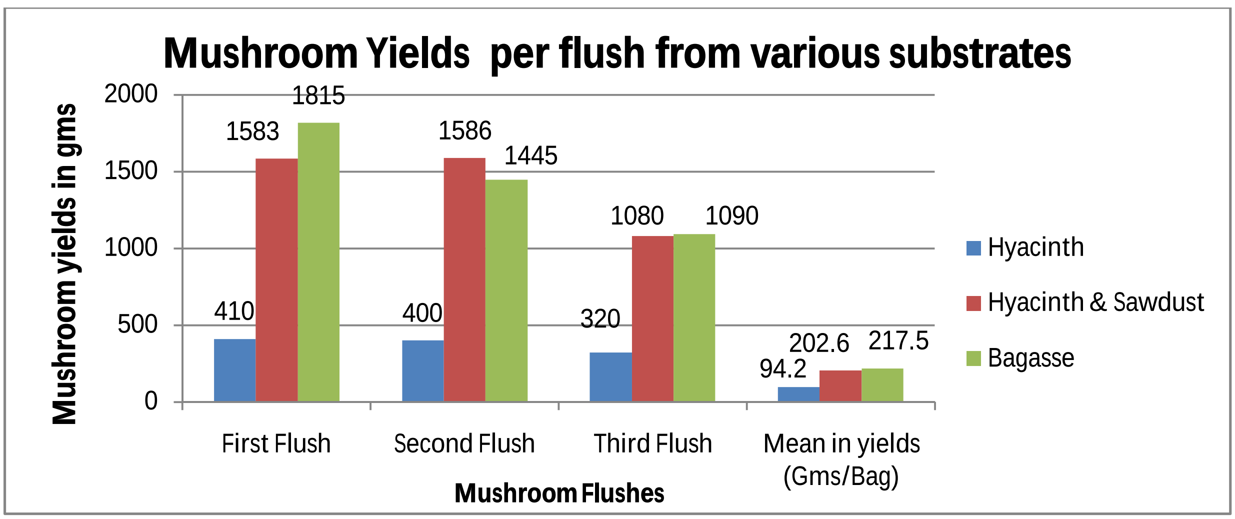
Table 3.2 Use of water hyacinth Substrate

Response	Frequency(n)	% Frequency	Cumulative %
Yes	159	99.4	99.4
No	0	0	0.6
Undecided	1	0.6	100.0
Total	160	100.0	

Source: Field data, 2013

According to table 3.2 above, 99.4% of mushroom growers were willing to use water hyacinth as substrate for mushroom farming, while 0.4% were undecided. Also when asked whether they will create time and visit Manyatta Centre in Vihiga where mushrooms have been produced using water hyacinth substrate obtained from Lake Victoria, 99.4% indicated that they were willing to visit the centre to learn. Perhaps the reason for the large number of farmers willing to use water hyacinth substrate for their mushroom farming activities could be attributed to the report of Kimenju e tal (2009),who reported that mushroom can be fruited on a variety of organic materials. Also Abound e tal (2005), has reported that water hyacinth is rich in nutrients because it occurs in nutrient rich environments which comprises of lakes and dams. Therefore water hyacinth substrate could be the best choice to Vimpro due to its availability in large volumes in Lake Victoria.

Table 3.3 Establishing yields per flush of mushrooms from water hyacinth substrate.



Source:Generated by the researcher,2013

According to the results presented in table 3.3 above, water hyacinth substrate used alone, first flush yielded 410gms of mushroom, second flush, 400gms and third flush 320gm.The overall yields achieved for the three flushes was 1130gms from 12 bags, giving an average of 94.2gms of mushrooms per bag containing 2kg of susbtrate .The study indicates that yields per flush decreased as the flushes advanced from first to third. This finding is in agreement with Kimenju etal, (2009), who recorded 32.2gms per flush from first flush, second 17.1gms and third 5.5, he also gave corresponding percentages as 69.6%, 23.6% and 6.8%, an indication that it's not economical to grow mushrooms using water hyacinth beyond third flush. The yields increased when the water hyacinth substrate was combined with sawdust substrate. The first flush yielded 1583gms, second 1386gms and third 1080gms. The overall yields for the three flushes was 4051gms, giving an average of 202.6gms per bag of 2kg. This finding differs with Kivaisi (2007), who reported 4 to 6 flushes with a yield of 643.4gm a bag when using varied substrates. Oei (2005) reported that the yield is expected to be 20% of the weight of the wet substrate which equally differs with results obtained. The period taken from inoculation to first harvest (flush) of mushroom when using water hyacinth alone was 37 days while when combined with sawdust substrate took 36.5 days, a half day shorter. This finding differs with Margaret Tagwira from Zimbabwe who indicated 30 days (McGrath, 2003).The maturity period is controlled by the growing conditions such as temperature and relative humidity. Among challenges facing Vimpro farmers, temperature and relative humidity are included. The farmers do not have basic instruments such as thermometers for monitoring these essential growing conditions, hence might have contributed to delayed maturity.

Examining the Relationship between Biomass and Yields per Flush of Mushrooms.

In examining the relationship between independent variable (Water hyacinth) and dependent variable (Mushroom) ,a computation was done using Pearson's coefficient of correlation(r).The result showed zero correlation in all the three flushes of mushrooms. This is an indication of none existence of the relationship between the two variables (Kothari,2006).The literature available do not show the correlations for even other substrates used in mushroom farming, hence a new area which require further investigation. Perhaps keeping the weight of the substrate constant, two kilogram per bag, could have resulted into zero correlation.

Table 3.4 Determination of gross margins and evaluation of Mushrooms

Substrate	**Gross Margins (Kshs)**	**Returns/Bag (Kshs)**
Water hyacinth	912.00	15.2
Water hyacinth&Sawdust	3746.60	62.4
Bagasse	4056.00	67.6

Source: Generated by the researcher, 2013

Gross Margins of Mushrooms and Cost-Benefits

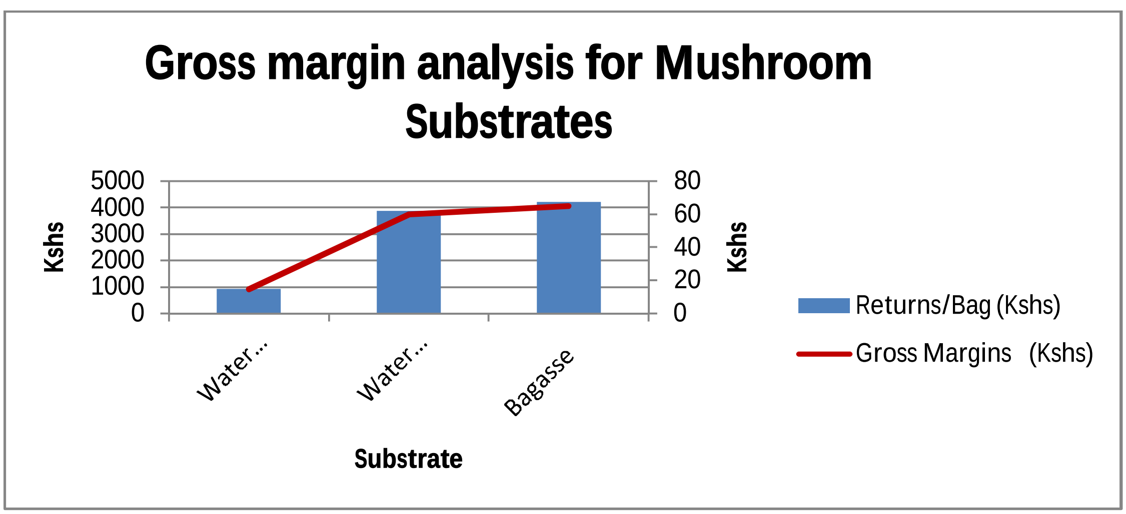


Table 3.4 above presents gross margins of mushrooms from three types of substrates, water hyacinth alone, water hyacinth &sawdust and bagasse. The results were kshs 912, kshs 3746 and kshs4056 from 60 bags of the wet substrate respectively, an indication that the gross margins of mushroom improved when water hyacinth substrate was combined with sawdust substrate. The gross margin per bag was kshs15.2 from water hyacinth substrate alone, kshs 62.4 when water hyacinth was combined with sawdust substrate at cost of kshs45.20. This result differs with Kivaisi (2007) who reported kshs113.60 per bag at a cost of kshs24.94 at Mbeya District in Tanzania using varied substrates. The probable reason for the big variance realized was due to low cost of production (kshs24.94) coupled with high yield, 560 gms per bag. However, studies have shown that water hyacinth has covered an area of 68000 ha in Lake Victoria, thus providing plenty of biomass(Oketch,2013).Therefore the cost of mushroom production would be reduced and yields improved to spur expansion of mushroom production in Vimpro which will be replicated in other parts of the country (McGrath, 2003).

4 RECOMMENDATIONS

The first objective of the study was to establish yields per flush of mushrooms from water hyacinth substrate. The findings and conclusion drawn showed low yields of mushroom when water hyacinth was used alone as substrate but yields increased substantially when combined with sawdust substrate. Therefore the study recommends that for better yields which translate to high income, the water hyacinth should be combined with other organic materials such as sugarcane trash, sawdust savings, banana leaves, maize cobs and husks. These are agricultural wastes which are available locally. The water hyacinth availability is set to be cheaper in terms of removal from Lake Victoria due to the proposal already made to use it for biofuel and fertilizer. Trainings of Vimpro farmers should be organized on how to balance the mixed substrates in order to achieve suggested better yields.

The second objective of the study was to examine the relationship between biomass and yields per flush of mushrooms. The results show that there was zero correlation between biomass of water hyacinth and yields per flush of mushrooms, an indication of no relationship between biomass and yields per flush of mushroom. Perhaps the constant weight of substrate, arising from the use of a bag weighing two kilograms could have contributed to this kind of result. It could be interesting to investigate what could happen if the weight is varied by using bags of different sizes ranging from 1.5kgs to 5kgs.

The third objective of the study was to determine gross-margins and evaluate cost-benefits of mushroom farming using water hyacinth substrate.The study revealed that gross margins and cost-benefit were low when water hyacinth was used alone, but improved when combined with sawdust. To optimize the use of water hyacinth substrate and get better returns, the study recommends that water hyacinth substrate should be used in combination with other organic materials. In this way, the potential seen in water hyacinth substrate can be exploited for growth of mushroom industry in Vihiga County which will be replicated also in other parts of the country in an effort to expand mushroom industry.

5. CONCLUSION

The overall objective of the study was to determine utilization of water hyacinth as an alternative substrate for mushroom farming in Vihiga Mushroom Project, Vihiga County. The first objective of this study was to establish the yields per flush of mushrooms from water hyacinth substrate. The findings showed that yields per flush of mushrooms was low from water hyacinth substrate when used alone and improved when its combined with sawdust . On the basis of these findings there was sufficient evidence to conclude that water hyacinth is a good substrate for mushroom farming. The second objective of this study was to examine the relationship between biomass and yields per flush of mushrooms. Pearson's correlation analysis was used to ascertain the relationship and the result was found to be zero. However, further research needs to be carried out on this objective. On the basis of these findings there is a clear evidence to conclude that there is no relationship between biomass of water hyacinth and yields per flush of mushrooms. The third objective of the study was to determine gross-margins and evaluate cost-benefit of mushroom farming using water hyacinth substrate. The study showed that the gross margin of water hyacinth improved from kshs912 when used alone to kshs3746 when combined with sawdust substrate. The cost and benefit per unit increased from kshs.77.70 per kg to kshs174.10/kg. On the basis of these findings there was sufficient evidence to conclude that gross margin and cost-benefit was high when water hyacinth is combined with sawdust or other organic material. Finally on the basis of these results as per the specific objectives, there is sufficient evidence to conclude that water hyacinth is an alternative substrate for mushroom farming in Vihiga Mushroom Project.

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