MultiCraft

International Journal of Engineering, Science and Technology
Vol. 16, No. 2, 2024 pp. 21-26

INTERNATIONAL JOURNAL OF ENGINEERING, SCIENCE AND TECHNOLOGY

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Affordable cost techniques for growing edible mushrooms

Washa Bugalama Washa

Department of Botany, Mkwawa College of Education, University of Dar es Salaam, Iringa, TANZANIA
**Corresponding author: washa.washa@muce.ac.tz, Tel+255 752 356 709*
ORCID: https://orcid.org/0000-0003-1709-9168

Abstract

Mushrooms are nutritious foods with medicinal value. Cultivation of mushrooms is hindered by poverty in Tanzania communities. A study to establish mushroom cultivation techniques at affordable cost was conducted at Kinyerezi Dare s Salaam Tanzania in 2022. Three replicate comprising greenhouse setup and substrate ratios comprising saw dust, banana leaves, grain chaff, lime and sugar were established and tested their production ability. Substrates were packaged in 100 bags of 2 kg each in their respective ratios 30:30:15:15:15, 25:25:10:10:10 and 20:20;5:5:5 where mushroom spores were inoculated and sparingly watered for 30 days to allow germination. Mushrooms were harvested twice a week for three months to record germination number and percentage. Data were analysed using SPSS version 16 for descriptive and inferential statistics. Obtained data were summarized into tables for interpretation and discussion. Woody greenhouse of palm frond created the most optimal conditions for mushroom growth which were 75% humidity, 25^{0}C and 7.5 pH. Substrate combination in a ratio of 20:20:5:5:5 with additional of extra 2 kg sugar produced highest germination percentage and number which were 17% and 172.8 respectively and indicated a significant difference between trials in germination percentage P=0.002248, df=2 but not significantly different in germination number P=0.25246, df=2. It was concluded that, edible mushroom can be grown at an affordable cost using woody greenhouse which influence optimal growth conditions, but also researchers on future should think on using constant substrate ratio while assessing the others to see if can alter germination number and percentage. It was recommended to the community to acquare the techniques so as to produce mushroom for health and economy.

Keywords: Edible mushrooms, cultivation, livelhood, substrate, greenhouse

DOI: http://dx.doi.org/10.4314/ijest.v16i2.3

Cite this article as:
Washa W.B. 2024. Affordable cost techniques for growing edible mushrooms. *International Journal of Engineering, Science and Technology*, Vol. 16, No. 2, pp. 21-26. doi: 10.4314/ijest.v16i2.3

Received: January 10, 2024; Accepted: January 27, 2024; Final acceptance in revised form: February 15, 2024

1. Introduction

Most of the African economies, livelhood and people's health are affected by persistent drought due to global climatic change and poor food production especially grains (Cotton, 1996, FAO, 1998). Cultivation of mushrooms grown in greenhouses can improve livelihood and economy of the African communities by selling them and improve health due to their nutritive values as suggested by Washa (2020) and Washa (2023). Cultivation of mushrooms in Africa is hindered by low economy as a result this type of cultivation has remained only to few investors who come from outside Africa (IM, 2022, TMIT, 2020). Edible mushrooms are nutritious foods with medicinal values while very few are poisonous (Washa, 2022, Washa, 2023). Mushrooms contain 80-95% moisture, 3% protein, 0.3-0.4%, fats and 1% vitamin and minerals and therefore should be available for human health (Msuya *et al*, 2008, Venturella *et al.*, 2015).

Pleurotus ostreatus as varieties of edible mushrooms, are one of preferably eaten mushrooms and easily cultivated by local grower and commercially leading species (Ogundele *et al*, 2014, Venturella *et al.,* 2015). *Pleurotus ostreatus* can be easily identified by presence of oyster-shaped cap, decurrently white gills that are running down the cap and stem. The caps are white to brown, smooth with no scales, a flesh stem is white with no rings and spores are white to lilac-gray (Tibuhwa and Kivaisi, 2010). Growing a mushroom in a controlled area (greenhouse) needs preparation and use of greenhouse constructing materials, substrate combination and ratios and the optimal growth conditions which are the results of what type of greenhouse materials used (Oh *et al*, 2004b). Many growers have been using either plastic, iron sheet or woody greenhouse material and woody materials have been recommended by many researchers as better than others. Among the frequently used substrates to form a growth media includes sawdust, grain chaff, lime, sugar, banana leaf slices and rice chaff. The performance of these substrates depends on their combination and ratios. Many researchers have recommended optimal growth conditions for mushrooms as higher humidity above 80%, low temperature below 25^0C and moderate acid and base around 7.5 pH (Oh *et al*, 2004b).

Many researchers including Oh *et al* (2004), Venturella *et al* (2015), and Washa (2023) have reported that higher germination, growth and proliferation of mushrooms and other fungi regardless of growth media (substrate) are totally dependent on higher humidity especially 80% or above which is influenced by greenhouse material or humidifier. It means that substrates can be changed depending on mushroom species but humidity should be 80% or above. Higher humidity have two effects in the greenhouse, one is to lower the temperature and second is to influence higher growth of mushrooms. Low humidity also have two effects in the greenhouse, one is to raise temperature and second the temperature will kill the mycelia of mushrooms to death (Oh *et al*, 2004, Venturella *et al*, 2015, and Washa, 2023).

Sugar is a carbohydrate yielding 3.94 calories per gram as do all carbohydrates. This stored energy in form of calories is used for initiating mushroom germination and growth (Venturella *et al.*, 2015). Sugar as part of the substrate is cheaper for local mushroom growers to buy than Agar of Murashige and Skoog used in technological laboratories (Murashige and Skoog, 2010). Grain chaff is composed of cellulose, lignin, hemicelluloses, and a protein matrix (Moonmoon *et al*, 2011). These compositions are nutritive materials to be absorbed by the mushroom through mycelia parasitically as mushroom fungi have parasitic mode of life. The composition also prevents solidification of the media (compost) to allow parasitic penetration of the mycelia. Grain chaff is the cheapest substrate to be bought by the local mushroom growers compared to the Agar used in technological laboratories. The composition of grain chaff presented in this research agree with the findings by (Oh *et al.*, 2004b). Lime is a calcium-containing inorganic mineral composed primarily of oxides, and hydroxide, usually calcium oxide and/ or calcium hydroxide.. Lime in the compost of this research was of two functions: One was to harden the mycelia but also the media. This means solidified the growth media to the required level to support standing of the germinated mycelia and harden the mycelia is when the flegile mycelia which is not able to stand by its own tissue, to some extend harden and mycelia can stand on its own. The other function of lime is to balance and maintain the pH of the media at optimal level as a growth requirement (7-8) (Gerrits, 1981). As it is, lime is cheaper than the Agar. The composition and functions of the lime substrate as elaborated in this research is in agreement with findings by (Chang and Miles, 1989). Woody materials (reject timber, stock wood and palm fronds) are poor conductor of heat used to minimize the destructive temperature to optimal level (22^0C). In additional to reduction of temperature, timber reject is used to retain darkness as a growth requirement (Moore and Chiu, 2001, Washa, 2015). Due to lack of techniques for cultivation of mushroom (Washa, 2022 and Washa, 2023), a simple technique with the objective of growing mushrooms which can be managed at an affordable cost was investigated for establishment and presentation to the community.

2. Material and methods

2.1 Description of the Study area

The study was conducted from March to June 2022 at Kinyerezi (6°50'27.2"S, 39°10'26.5"E) in Dar es Salaam. Kinyerezi as indicated in Figure 1 is a place where individuals and super markets demands mushroom for their daily consumption but also woody materials such as reject timber, stock wood and substrate materials such as grain chaff, saw dust and banana leaves can be easily obtained in the family environment at an affordable cost. This is why the place was selected for the investigation.

2.2 Collections of materials

Materials collected included: Timber reject, stock wood, palm tree leaves (palm fronds), nails, iron sheets, grain chaff, saw dust, dry banana leaves, lime, sugar, firewood, drums, 1kg plastic bags, bottles containing mushroom spores (*Pleurotus ostreatus*) which is edible and can be easily cultivated and domesticated as per Washa (2022:2023), tape measure, a watch, thermometer and pH meter. Each item was collected or purchased in a number which can satisfy three local greenhouses with different growth conditions and three substrate combination and ratios. All three replicate trials were conducted at the same time (March-June 2022) and the same environments but vary in woody material types, substrate (growth medial ratios) and optimal conditions.

2.3 Methods Research design

A split plot design was used to design the experiment where greenhouse material and substrate ratios were used as main and the three replicates were used as sub-plots while the growth conditions were results of greenhouse setup (Zar, 2010). First trial comprised greenhouse of reject timber wall and iron sheet roof, second trial of reject timber wall and reject timber roof, third trial of palm fronds wall and palm fronds roof. Growth media ratio (sawdust, grain chaff, banana leaves slices, sugar and lime) in the first trial was 30:30:15:15:15, second trial was 25:25:10:10:10 and the third trial was 20:20:5:5:5. The Greenhouse setup and substrate ratios were replicated three times to optimize the results (Zar, 2010). Each greenhouse setup was expected to influence different growth conditions level (humidity, temperature and pH). Each growth condition level was expected to result into different germination percentage and germination number after three months of recording to enable statistical analysis and comparison (Zar, 2010).

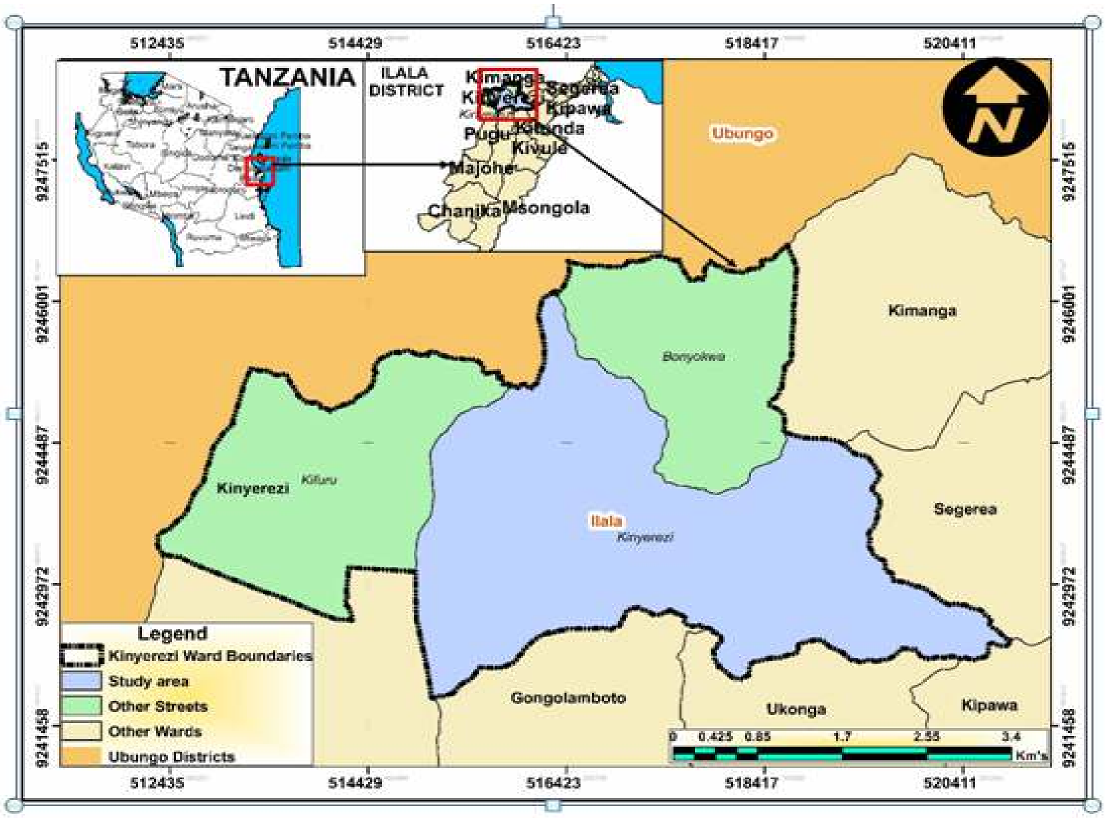

Figure 1: Map showing the study area

2.4 Sample preparation and methods

Boiling of substrates (to sterilize substrates at a boiling temperature) and soaking duration of substrates remained constant in all trials which were 4 days soaking (to provide necessary moisture content for the mycelium to grow) and 4 days drying duration, 4 hours boiling at boiling temperature and 24 hours cooling the materials. At a sterile condition, different ratios of sugar and lime was added to cooled combination of saw dust, grain chaff and dry sliced banana leaves before packaging them into 100 plastic bags of 2 kg each. Only one trial (third trial) was added an extra 2 kg sugar to each of the growth media bag to check if differences in germination can arise as the effect of sugar. Inoculation of mushroom spore was done to each of both sides of a 2 kg growth media bag, then were closed and placed in the dark area for 30 days for the spores to colonize the growth media. Growth media were opened and sparingly watered for 30 days to enable mushrooms germination. Mushrooms were harvested twice a week for three months to record germination percentage and germination number (Washa, 2023).

2.5 Data analysis

Data obtained were analyzed using SPSS (Version 16) for descriptive and inferential statistics where germination number and germination percentage were obtained and presented on Figure 2 and 3. Tested material arrangements, substrate ratios and recorded optimal conditions were also presented in Table 1 to enable interpretation and discussion.

3. Results and Discussion

Table 1. Mean of replicates of substrate ratios, optimal conditions and germination results

Trial number	Greenhouse materials	Substrate ratios	Optimal conditions	Germination %, germination number
1	Timber reject, stock wood, iron sheet	30:30;15:15:15	65%, 30°C, 8 pH	5-7%, 20-25
2	Timber reject, stock wood, palm fronts	25:25;10:10:10	70%, 27°C, 7.7 pH	7-15%, 25-34
3	Palm fronts, stock wood, palm fonds	20:20:5:5:5	75%, 25°C, 7.5 pH	7-16.5%, 52-173

3.1 Influence of humidity on germination results

3.1.1 Observations on germination percentage

There is an increasing trend in germination percentage from trial 1 to trial 3.

3.1.2 Observations on germination number

The germination number vary significantly between trials with trial 3 having a notably wider range (52-173) compared to trial 1 (20-25) and trial 2 (25-34)

3.2 Significant Differences in Germination Percentage

There seems to be an increasing trend in germination percentage across the three trials. Mean germination percentage in the third trai indicated a significant difference (p = 0.002248, df = 2) as indicated in Figure 3.

3.3 Significant Differences in Germination Number

There is a substantial difference in germination numbers between trials, especially with Trial 3 exhibiting a wide range (52-173). This suggests potential variability in germination performance, however, the increase in mean germination number between trials was statistically not significant P=0.25246, df = 2 as indicated in Figure 2. The overall observation of the study on the greenhouse materials, substrate ratios, optimal conditions and the factors facilitated the creation of optima conditions are presented in this discussion. The results from the three trials reveal notable variations in germination percentages and numbers, greenhouse materials, substrate ratios, and optimal growth conditions. Trial 1 exhibited the lowest germination percentage (5-7%) and a relatively stable germination number (20-25). In contrast, Trial 3 showed the highest germination percentage (7-17%) with a significantly wider range of germination numbers (52-173). These differences suggest that the choice of greenhouse materials, substrate ratios, extra additional of sugar and growth conditions significantly impacts mushroom germination and growth. This observation is in agreement with findings by Oh et al. (2004b).

The selection of greenhouse materials plays a crucial role in maintaining optimal conditions for mushroom cultivation agreeing with findings by Washa (2023). In Trial 1, the use of timber reject, stock wood and iron sheet resulted in a lower germination percentage compared to Trials 2 and 3, where palm fronds were introduced. The introduction of palm fronds in Trials 2 and 3 correlated with an increase in germination percentage, suggesting a potential positive influence on the germination process. The variation in substrate ratios across trials also contributes to the observed differences in germination outcomes agreeing with findings by Venturella *et al.* (2015, Oh *et al.* (2003) and Okgibo *et al.*, (2021). While Trial 1 had a balanced ratio of 30:30;15:15:15, Trials 2 and 3 incorporated palm fronds in varying proportions (25:25:10:10:10 and 20:20:5:5:5, respectively). The inclusion of palm fronds in the substrate mixtures may have provided additional nutrients or favourable conditions for germination and growth, contributing to the improved outcomes seen in Trials 2 and 3. Extra addition of sugar in trail 3 have resulted the most higher germination percentage and germination number in this trial suggesting that the more energy is added in the media the more germination is trigged. The optimal growth conditions, including temperature and humidity, differed slightly across trials. Trial 3, with the highest germination percentage and widest range of germination numbers, maintained a higher temperature (25^0C) compared to Trials 1 and 2. This suggests that an elevated temperature might have a positive impact on mushroom germination, the observations agree with findings by Chang and Miles (1989).

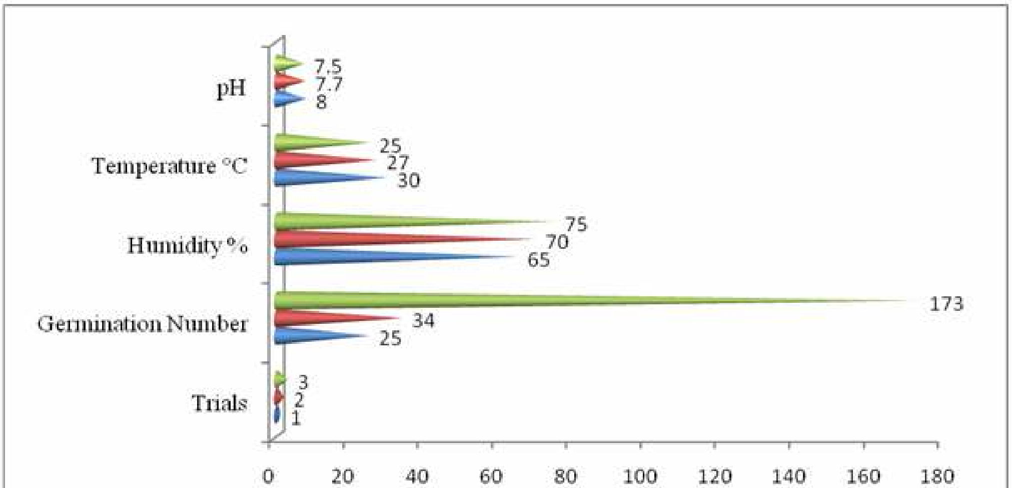

Figure 2: Germination Number across trials

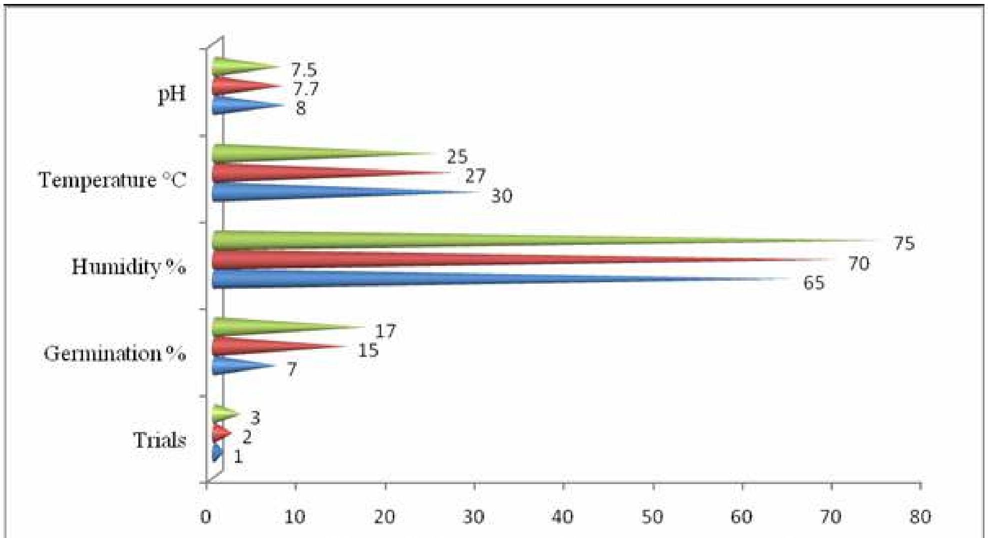

Figure 3: Germination Percentage across trials

4. Conclusion

The results indicate that the choice of greenhouse materials (palm fronds), substrate ratios (20:20:5:5:5), and optimal growth conditions (75%, 25°C and 7.5 pH) significantly influence mushroom germination and growth. The inclusion of palm fronds in the substrate mixtures appears to have a positive impact on germination outcomes. Sugar is a crucial substrate to provide germinating energy. Additionally, variations in temperature may play a role in optimizing germination performance especially at low temperature (below 25^0C) which allow grow of the mushroom mycelia but also low temperature raise humidity which can be maintained at 80% or above. However, researchers on future should think on using one element (the substrate ratio is held constant while assessing the others to see if can affect growth number and percentage. It is recommended to researchers to optimize the growth conditions, substrate ratios and greenhouse materials for higher mushroom productivity. Optimization can be achieved by conducting more research. It is also recommended to community to acquire the technique for mushroom cultivation.

Acknowledgement

I acknowledge the travelling and research permission given by the management of Mkwawa University College which lead to conduction and completion of this research. More appreciation also goes to all colleagues and members who in one way or another contributed

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Biographical notes

Dr. Washa B. Washa is a researcher in *Dalbergia melanoxylon* (African Blackwood), *Swartzia madagascariensis, Baphia kirrkii*, *Tetradenia raparia* and *Pleurotus ostreatus* (Oyster mushrooms). Dr. Washa has been a paper reviewer in various Journals including Tanzania Journal of Science (2012), International Journal of Plant and Soil sciences (2019), Recent Journal of Science and Technology (2020) and the Journal of Cell Biotechnology and molecular Biology (2020). He has also extended his research efforts into *Swartzia madagascariensis*, *Baphia kirrkii*, *Tetradenia raparia* and *Pleurotus ostreatus.* Dr. Washa is a Senior Lecturer in Botany at Mkwawa University College of Education, Biological sciences Department, specialized in Plant physiology, plant Anatomy, Mycorrhizae and plant Tissue culture from 2008 To date.