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Evaluating the production of *Ganoderma* mushroom on corn cobs

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Mushroom substrates are organic materials which mushroom mycelia can digest and which support growth, development and fruiting of mushrooms. Without good substrates, satisfactory yields of mushrooms will not be obtained. Consequently, finding good substrates on which to grow *Ganoderma lucidum* is of great importance to the medicinal world, and for mushroom farming in Namibia. The objective of this research was to determine the possibility of growing *G. lucidum* mushrooms on corn cobs as a substrate base in order to see if corn cobs can replace saw dust as a substrate of *Ganoderma* cultivation in Namibia. The corn cobs and saw dust (control) were sterilized, inoculated under aseptic conditions in clear plastic bags and incubated at room temperature. Fruit bodies were observed within 30 to 50 days, results considerably shorter compared to when using saw dust, which can take up to four months before mushrooms are obtained. This study demonstrated that corn cobs can be used as a substrate if supplemented with nutrients to support growth of the basidiocarp.

Key words: *Ganoderma*, corn cobs, substrate, mushrooms, sawdust, basidiocarp.

INTRODUCTION

Ganoderma lucidum, a medicinal mushroom, is among the most popular herbal medicines in East Africa that has been used to modulate immune functions, inhibit tumor growth and in the treatment of chronic conditions like hypertension and hyperglyceamia (Jan et al., 2011). Mushroom cultivation techniques which use methods such as submerged culture to obtain mycelium have been described during the last 15 to 20 years while solid culture is used to obtain fruiting body or basidiocarp on several types of substrate and by monitoring important growth parameters including temperature, relative humidity and pH (Gurung et al., 2012; Erkel, 2009). The organic materials which can be digested by mushroom mycelia and support growth, development and fruiting of mushrooms are called substrate (Kadhila-Muandingi and Mubiana (no date)). Hence, without good substrates, satisfactory yields of mushrooms will not be obtained. Erkel (2009) wrote that for most medicinal mushrooms of the basic substrate is hardwood sawdust (75 to 80%) from deciduous trees like maple and elm, supplemented with wheat bran, although rice bran, rice husks, coconut fiber, peanut hulls, corn, sorghum and sugarcane bagasse and rice bran, ground corn and ground sorghum were found to be good supplements for substrate

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Table 1. The biological efficiency obtained from corn cobs and saw dust.

Parameter	Corn cob	Sawdust
Weight of Substrate (kg)	3.80	3.30
Weight of Mushrooms harvested (kg)	0.202	0.00172
Biological efficiency (BE) in % [Weight of mushrooms/ weight of substrate x 100%]	5.32	0.05

mixture. In Nepal, *G. lucidum* had been cultivated on four different substrate mixtures with sawdust 70 to 90% supplemented with rice bran 10%, corn meal 20% and wheat bran 10% and wheat bran 12% (Gurung et al., 2012). In another study, corn cobs were used as a lignocellulosic substrate for the production of lignin peroxidase by *G. lucidum* (Mehboob et al., 2011). From the above examples, it appears that corn cobs have successfully been used in the cultivation of Ganoderma, but mostly as a supplement to a substrate base of sawdust or to grow mycelia instead of cultivating the basidiocarp.

Maize is the major commercial crop produced in Namibia (Mushendami et al., 2008). The cultivation of *G. lucidum* on corn cobs, which are an agricultural waste, could increase the availability of substrates in Namibia, and thus increase its production. Namibia is a dry and arid country. Trees that can provide good quality sawdust are mostly found in the Kavango region (http://www.openafrica.org/route/Kavango-Open-Africa-Experience), making it expensive to transport sawdust to be used in mushroom cultivation. Finding alternate substrates on which to grow *G. lucidum* will help to cut on transportation costs and allow people to use corn cobs which are more widely available (Philippoussis et al., 2003). The objective of this research was to determine the possibility of growing *G. lucidum* mushrooms on corn cobs as a substrate base in order to see if corn cobs can replace saw dust as a substrate of Ganoderma cultivation in Namibia.

METHODOLOGY

Preparation of culture

Ganoderma lucidum culture was obtained from the ZERI laboratory at the University of Namibia and used to multiply more cultures. Potato dextrose agar was prepared according to instructions on label. The pure culture was multiplied by aseptically cutting small blocks and placing them on the fresh potato dextrose agar in Petri dishes. The Petri dishes were covered and sealed with Para film to prevent contamination. After 6 days, the mycelia had covered most of the surface of the agar.

Development of spawn

Dry wheat grains weighing 253 g were soaked in water overnight before the grains were removed; rinsed and excess water was drained. The grains were mixed with 1.5% of lime to alter the pH and packed in plastic bottles. The bottles were half-filled and closed lightly to autoclave at 121°C for 15 min. The grains were cooled and inoculated with 3 to 4 pieces of the pure culture obtained after which the bottles were stored in a cardboard box at room temperature to allow for mycelia growth. After 2 weeks, the grains were fully invaded by mycelia and the spawn was ready for substrate inoculation.

Substrate preparation

Mushroom substrates are organic materials that support the growth, development and fruiting of the mushroom mycelia. The substrates used were corn cobs and saw dust (control). The corn cobs and saw dust were weighed and soaked in water overnight (Table 1). The next day, the water was drained off and a handful of wheat bran was mixed with both substrates and substrates were packed into autoclavable plastic bags and autoclaved for 15 min at 121°C. The prepared substrates were transferred to smaller 'houtsak' plastic bags after cooling and inoculated with pure Ganoderma spawn using aseptic techniques. Finally, the bags were transferred to the dark room to allow mycelia growth. This step was replicated on four different days.

Fruiting phase

Once the bags were fully invaded by mycelium they were taken to the fruiting room where temperature and humidity was controlled to allow fruiting of the mushrooms. A blade was used to make openings on the bags to allow mushroom pinning. Daily watering of the fruiting room was necessary to raise the humidity and lower the temperature.

RESULTS

Pure cultures

A thick white carpet of pure Ganoderma culture was obtained after six days (Figure 1). Some plates had to be discarded because they showed signs of Trichoderma contamination.

Development of spawn

Pure spawn was obtained within two weeks of inoculating the grains (Figure 2).

Figure 1. Ganoderma pure culture.

Figure 2. Pure spawn.

Fruiting phase

Fruiting has been observed in corn cobs substrate but none in some bags or poor fruiting in other saw dust bags (Figures 3 and 4).

DISCUSSION

Ganoderma cultivation at the University of Namibia is usually done using hardwood sawdust or woodchips as substrate. However, it is a long process which takes up to 5 months before mushrooms can be obtained. Thus, there is a need to find alternative substrate which can support the growth of this important mushroom. Saw dust was used as a control to compare the growth of Ganoderma on corn cobs. The results observed indicated that mycelia invasion of the corn cobs was faster than in saw dust (Figure 5) and some of the bags produced very small mushrooms; according to Kadhila-Muandingi and Mubiana (no date), this may occur when a number of mushrooms are growing from one bag at the same time and there is a lack of nutrients in the substrates. Previous studies indicated that corn cobs have been used as supplement for growth of *G. lucidum* in combination with other substrates such as rice bran and saw dust (Lakshmi, 2013), but has not been used as a base substrate on its own.

In this study, Ganoderma grew on corn cobs with a BE of 5.32% while saw dust had a minimal BE of 0.05%. In previous studies, Erkel (2009) grew Ganoderma on Poplar, Beech and Oak sawdusts and obtained an average BE of 15.09% while Azizi et al. (2012) achieved a BE of 12.89% on Hornbeam sawdust and a high 18.68% on Poplar sawdust. Veena and Pandey (2010) reported a BE ranging from 4 to 13% when they cultivated *G. lucidum* on locally available saw dust in India. The yield of *G. lucidum* on both saw dust and corn cobs obtained in this study was very low, when compared to the previous studies. There is therefore need for continuous efforts to be made in order to find suitable substrate combinations and supplements to increase yield of mushrooms from locally available agro-industrial substrates in Namibia. The substrates were exposed to the same environmental conditions, thus it can be assumed that the differences in the yield of mushrooms obtained was caused by differences in the substrates. Corn cobs have a higher ability to retain moisture compared to sawdust which dries out much faster. Additionally, substrates which have a high cellulose and lower lignin content allow mushrooms to pin faster than those which have high lignin and low cellulose. This is because high cellulose substrates have carbon available for rapid breakdown during mycelia growth whilst lignin takes longer to decompose. Corn cobs and wheat straw contain higher cellulose, crude proteins and moisture content than saw dust and sugar cane bagasse (Onyango et al., 2011). In the Namibian context, corn cobs is an ideal substrate for Ganoderma mushroom cultivation, especially considering that it is a farm produce which is inexpensive and widely available (Samuel and Eugene, 2012). The quality and yield of mushrooms depend on different factors such as the quality of spawn used, type of substrate, climatic factors and nutrients supplemented to the substrate before and at the time of fruiting (Khare et al., no date). It is recommended that corn cobs can be used as a substrate if supplemented

Figure 3. Corncobs (L) and sawdust (R) growing in bags.

Figure 4. Ganoderma growing on maize cobs.

with nutrients to support growth of the basidiocarp.

It is also recommended that quality assurance tests be done on the mushrooms obtained to ensure that their bioactive compound content are the same as mushrooms cultivated on hardwood sawdust. Additionally, the content of lignocellulose on corn cobs and saw dusts should be evaluated and, it is advised that materials containing corn cobs as supplement should be another control, in order to

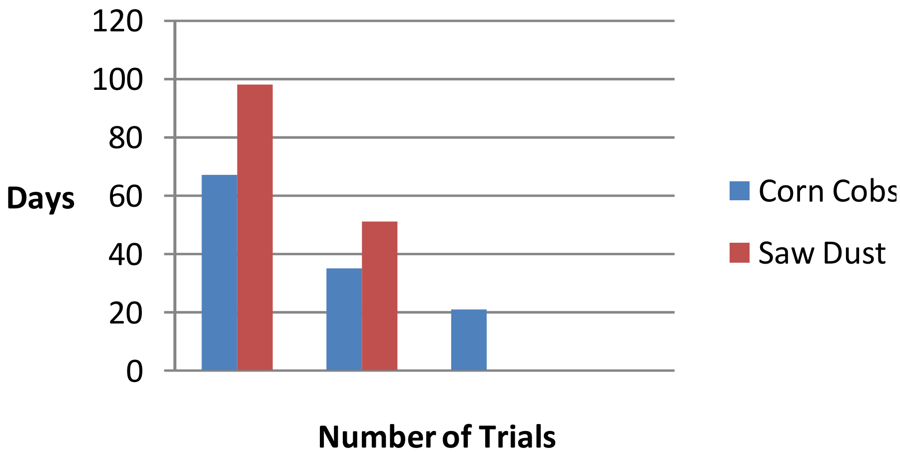

Figure 5. Graph showing the number of days it took for corn cobs and saw dust to grow.

indicate the advantage of corn cobs more clearly.

Conclusion

The objective of this research was to determine the possibility of growing *G. lucidum* mushrooms on corn cobs as a substrate base in order to see if corn cobs can replace saw dust as a substrate of Ganoderma cultivation in Namibia. In the results obtained, corn cobs had a BE of 5.32%, which was higher than the saw dust BE of 0.05%. It can be concluded that corn cobs have the potential to be used as alternate substrate for Ganoderma mushroom cultivation in Namibia.

Conflict of Interests

The author(s) have not declared any conflict of interests.

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