RESEARCH ARTICLE

GROWTH AND YIELD RESPONSE OF OYSTER MUSHROOM *(Pleurotos ostreatus)* ON DIFFERENT RATIOS OF RICE HUSK AND CORNCOB SUBSTRATES

Kristine M. Mangilog, Jessa Fae M. Mendez, Rochelle V. Soriano
College of Agriculture, Occidental Mindoro State College
kristine.mangilog.manongsong@gmail.com

ABSTRACT

This study investigated the growth and yield of oyster mushrooms using different substrate materials in a Completely Randomized Design utilizing four treatments: T_0 (100% sawdust), T_1 (25% rice husk + 75% corncob), T_2 (50% rice husk + 50% corncob), and T_3 (100% corncob). The experiment was conducted at Occidental Mindoro State College, College of Agriculture from June to October 2023. Polypropylene plastic bags were filled with different substrate combinations, pasteurized for 8 hours in a fabricated steel drum, and inoculated with oyster mushroom spawns. After colonization, the bags were placed in a growing house. Data were gathered from ten randomly selected fruiting bags per treatment. Results showed that 100% corncob significantly improved substrate efficiency by lowering the number of days to full inoculation and days to first flushing, increasing weight of oyster mushrooms, and biological efficiency. In addition, 100% corncob had comparable effects to 100% sawdust in terms of the number of fruits per flush and percentage marketable harvest. These findings suggest that corncob substrate, particularly 100% corncob, can be a viable alternative for oyster mushroom cultivation. It offers faster colonization, increased mushroom weight, and improved biological efficiency.

Keywords: *corncob, rice husk, colonization, spawn, oyster mushroom*

INTRODUCTION

Farmers like to grow oyster mushroom, however, there is a scarcity in finding a sawdust producer in their area as a substrate for growing them. Sawdust is the primary component of the mushroom oyster substrate media; it is necessary to investigate possible replacement materials. The chosen replacement substance must resemble sawdust in qualities and provide enough nutrients to sustain the development of the mushroom oyster (Rambey, et al., 2018).

According to Tesfaw et al. (2015), tropical and subtropical regions have substantial amounts of underutilized lignocellulosic by-products accessible to them. Typically, these waste items are burned or allowed to decay on the field. Growing mushrooms on readily available lignocellulosic substrate is another way to transform these unused wastes into recognized edible biomass with superior nutritional and commercial qualities. Due to their high nutrient content, agricultural wastes should not be disposed of without first being pre-treated to prevent leaching into the soil and potential harm to the ecosystem. This makes disposing of agricultural wastes a big challenge in the modern world. The most environmentally friendly solution to this issue is mushroom culture on these agricultural wastes, which lowers the level of nutrients to an acceptable range for use as manure. It enables to mushroom farmers to recycle garbage to save the environment and to get substrate materials at little or no cost (Khan et al., 2013). These wastes include rice husk, and corncob are locally available in the province of Mindoro.

Rice and corn are the first and second most-significant crops in the Philippines. In the year 2021, 19.96 million metric tons of rice and 8.12 million metric tons of corn produced. Therefore, there are 20% of rice husk and 18% of corncob produced as waste that frequently burned on the field or dumped by the side of the road by farmers and millers (Zhang et al., 2012).

About 35–40% of rice husk is made up of cellulose, 15–25% hemicellulose, and 25–25% of lignin. (Kumar et al., 2009). While corn cob contain lignocellulose, a substance required for fungus growth, they can be utilized as a substrate for planting mushrooms. Corn cobs contain 31-33% hemicellulose, 3-5% lignin and 40–44% cellulose (Wang et al., 2011). Therefore, it can be alternative to sawdust.

Occidental Mindoro, there are scattered agricultural by-products such as rice husk and corncob. Therefore, in order to minimize waste and to find alternative to sawdust, this study aimed to use locally available by-products to produce an edible mushroom.

The general objective was to conduct the effect of different substrate on the growth and yield of oyster mushroom in rice husk and corncob. Specifically, the study sought to: Determine the growth response of oyster mushroom in different substrate. Find out how oyster mushrooms respond in terms of yield on various substrates. Analyze the differences in effects of rice husk and corncob substrates on the growth and yield of oyster mushroom.

MATERIALS AND METHODS

Research Design

The study used a completely randomized design (CRD). It was done in a growing house where temperature and humidity were similar. Sampling was done randomly to avoid bias using draw lots to determine the corresponding treatments in the experimental layout.

Preparation

One kilogram (1 kg) of the substrate was placed inside the polypropylene bag. Thirty fruiting bags were prepared per experimental treatment. Only 10 fruiting bag were randomly chosen as samples. Each of the treatments was replicated three times. The substrates were filled and mixed with different mixtures (Table 1).

Table 1. Experimental treatments.

TREATMENT NUMBERS	MAJOR SUBSTRATE INGREDIENTS (78%)			SUPPLEMENTED INGREDIENTS			TOTAL
	Sawdust	Rice Husk	Corncob	Rice bran	Molasses	Limestone	
0	100%	-	-	20%	1%	1%	100%
1	-	25%	75%	20%	1%	1%	100%
2	-	50%	50%	20%	1%	1%	100%
3	-	-	100%	20%	1%	1%	100%

Source: Elsisura et al. (2022)

The process began with pasteurization, where the bags were steamed in an improvised pasteurizer—a 200L capacity steel drum—for 8 hours. After steaming, the bags were allowed to cool down, and the top of the pasteurizer was covered with an improvised lid to maintain the necessary conditions.

For the preparation of spawn, white oyster mushroom spawn was procured from a reliable source. Ten grams of this spawn were placed in each fruiting bag. Each bag was fitted with a PVC ring at the opening and then sealed with a rubber band and paper.

The incubation period commenced one week after introducing the spawn into the substrate. Fruiting was initiated once the bag was fully colonized by the mycelium.

During the fruiting phase, conditions required 80–85% relative humidity, proper light ventilation, and a temperature not exceeding 28°C. To maintain adequate moisture, the mushroom growing house was watered once daily, and the bags were kept closed to prevent moisture loss.

Cultural Method

The experiment was watered with clean water using hand sprayer twice daily. This was done to ensure the humidity level of the environment was maintained until the mushroom had taken enough water to induce production of fruiting bodies.

For harvesting, the ideal size of oyster mushrooms is indicated by an enlarged oyster mushroom body cap, at which point they are suitable for harvest. After the fruiting body was fully extracted from the substrate, harvesting was completed. In order to make sure the stem was undamaged, it was done by gently twisting and pulling them from the substrates. Following the start of primordia, oyster mushrooms matured in two to four days. Harvesting intervals lasted one to two days each. Amin et al. (2007) described that the mature fruiting body could be distinguished by its cap's curve margin.

Data Gathering Procedure

The data collection for this study involved several key parameters monitored across 10 fruiting bags. The days to full inoculation were recorded, referring to the duration required for the mushroom mycelium to completely colonize the substrate from the date of spawning, with daily observations made. The days to first flushing were noted as the number of days from inoculation until the initial flush of oyster mushrooms, documented through observations post-full inoculation. The weight of oyster mushrooms per flush was measured using a digital scale, capturing the total fresh weight of mushrooms harvested per flush. The number of fruits per flush was counted, referring to the fleshy, spore-bearing bodies of the fungus, and recorded for each bunch of mushrooms harvested. The percentage of marketable harvest was calculated by:

$$Percentage\ of\ marketable\ harvest \quad = \frac{\text{Total weight of marketable mushroom}}{Total\ weight\ of\ harvested\ mashroom} \quad X\ 100$$

Finally, biological efficiency was determined:

$$Biological\ efficiency\ (BE) = \frac{\text{weight of fresh fruiting body (g)}}{\text{weight of dry substrate (g)}}\ X\ 100$$

Data Analysis

The gathered data were collated, tabulated, and analyzed using analysis of variance (ANOVA). Tukey HSD was used to detect the significant difference among the experimental treatments.

RESULTS

The table below presents the parameters tested as affected by different ratio of rice husk and corn cob for substrates.

The result of the study revealed that T3 (100% corncob) obtained the shortest days to full inoculation (mean=19), followed by T1 with 29 days and T2 with 27 days. The longest days to fully inoculate substrate was observed in T0 (100% sawdust). Likewise, T3 with 100% corncob obtained the shortest days to first flushing (mean=32 days). It is followed by 50% corncob with 49 days and 75% corncob with 52 days. The longest days to first flushing was observed in T0 with 100 sawdust.

For the yield performance of oyster mushroom, T3 with 100% corncob obtained the heaviest weight of fruit per flush, number of fruits per flush, and biological efficiency with 71g, 26, and 24%, respectively. Consequently, T3 (mean=80%) is comparable with the result of T2 (mean=84%) in terms of percent marketable harvest (Table 2).

Table 2. Growth and yield response of oyster mushroom (*Pleurotos ostreatus*) applied with different ratios of rice husk and corncob substrates.

TREATMENTS	DAYS TO FULL INOCULATION	DAYS TO FIRST FLUSHING	WEIGHT OF OYSTER MUSHROOM PER FLUSH (g)	NUMBER OF FRUITS PER FLUSH	PERCENT MARKETABLE HARVEST (%)	BIOLOGICAL EFFICIENCY (%)
T_0 (100% sawdust)	49^c	77^c	45^b	26^a	88^a	7^c
T_1 (25 % rice husk + 75 % corncob)	29^b	52^b	48^b	15^b	78^b	12^b
T_2 (50% rice husk + 50% corncob)	27^b	49^b	43^b	18^b	84^{ab}	11^{bc}
T_3 (100% corncob)	19^a	32^a	71^a	26^a	80^b	24^a

For the result of the analysis of variance, highly significant difference was observed in all the parameters as evidenced by the computed p-value ≤ 0.01, thus rejecting the null hypothesis. The different ratios of rice husk and corncob substrates had significant effects on all the growth and yield parameters of oyster mushrooms, with varying degrees of consistency as reflected in the coefficient of variation for each parameter (Table 3).

Table 3. Analysis of variance on the growth and yield response of oyster mushroom *(Pleurotos ostreatus)* applied with different ratios of rice husk and corncob substrates.

PARAMETER	COMP F-VALUE	COMP P-VALUE	COEFFICIENT OF VARIATION
Days to inoculation	303.48**	<0.001	4.11%
Days to flushing	76.52*	<0.001	5.16%
Mushroom weight per flush	23.90**	<0.001	8.71%
Fruits per flush	15.38**	<0.001	14.25%
Marketable harvest	14.17**	0.01	3.08%
Biological efficiency	41.91**	<0.001	3.81%

DISCUSSION

The result for the days to inoculation coincides with the study of Samuel and Eugene (2012) where corn cobs and palm cones had the greatest mycelium running rate. They stated that the most likely reason for the increased rate of mycelium running in maize cobs and palm cones was the proper ratio of lignin, hemicellulose, and alpha cellulose.

On the other hand, the findings indicate that using 100% sawdust required the most time to fully inoculate, making it the slowest among all treatments. This slow performance aligns with the study by Decena and Del Rosario (2022), which also found that substrates with high concentrations of coconut sawdust, either alone or mixed with rice straw, resulted in slower spawn running. The delay in spawn running is attributed to the physical characteristics of sawdust, which impedes the flow of mycelium. The data suggests that higher sawdust concentrations slow down mycelial growth, making it less effective compared to substrates like rice straw, which allow for faster mycelial penetration.

According to Dhakal et al. (2020), the growth and yield of oyster mushrooms grown on corn cobs outperformed those grown on sawdust as a substrate. Sawdust and corn cob can be combined to boost oyster mushroom production. In contrast, according to Adjapong et al. (2015), although sawdust is widely regarded as the ideal substrate for mushroom production, maize wastes either alone or in combination with rice bran have also demonstrated to be successful substrates for oyster mushroom farming. According to Erlinda et al. (2021), since the concentrations of cellulose, lignin, pentosan, and other materials fluctuate with each treatment, the mycelium grows at a varied rate. With treatments that have less lignin because a big fungus can characterize the lignin content, the mycelium grows faster.

Also, the study suggests that using 100% corncob as a substrate is highly effective in promoting the rapid development of oyster mushrooms. On the other hand, the findings indicate that using a mixture of rice husk and corncob as a substrate significantly improves the growth rate of oyster mushrooms compared to using sawdust alone. Specifically, the treatments with 25% rice husk plus 75% corncob and 50% rice husk plus 50% corncob showed similar and faster growth rates, requiring 52 and 49 days, respectively, to reach a particular growth stage. This suggests that these combinations are more effective substrates than sawdust, which, as the control, showed the slowest growth with 77 days. The poor performance of the sawdust substrate highlights its inferiority compared to the rice husk and corncob mixtures in promoting faster mushroom development. The result was supported by the study of Hultburg et al. (2023), stating that the substrate consisting solely of sawdust would result in longer fruiting body formation. The mushroom fruiting bodies could be harvested between days 35 and 45 in the said treatment. The result was supported by the study of Sanchez (2010) which Pleurotos ostreatus in commercial production requires three to four weeks from inoculation to the harvest of the first flush.

The findings reveal that mushrooms grown in 100% corncob achieved the highest mean weight of 71g, followed by 25% rice husk + 75% corncob and 100% sawdust with mean weights of 48g and 45g, respectively. Despite these variations, there was no statistically significant difference among these three treatments in terms of mushroom weight per flush. Conversely, the 50% rice husk + 50% corncob mixture resulted in the lowest mean weight of 43g, consistent with previous research suggesting that a lower concentration of rice husk is more effective for producing higher yields of nutritious oyster mushrooms (Assan & Mpofu, 2014), where they recommended of the 2% concentration of rice husk as an alternative additive to composted sawdust for producing more nutritious oyster mushrooms. This was further supported by Costa et al. (2023), claiming that if raw rice husk is selected as a substrate, the amount used should not exceed 50% of the volume of the substrate. Otherwise, poor production and biological efficiency may result from the substrates' poor nutritional quality.

The results show that 100% corncob produced the highest number of fruits per flush, followed by 100% sawdust, with no statistically significant difference between these two treatments. In contrast, 50% rice husk + 50% corncob and 25% rice husk + 75% corncob produced the fewest fruits per flush. Muchsin et al. (2017) stated that adding rice husk to the growing medium can lead to a reduction in the quantity of mushroom fruit bodies. It is thought that the accumulation of silica, which oyster mushrooms cannot decompose, is the cause of this decline. Due to this, the mushroom's growth and development may be hampered by the presence of rice husk in the growing media, which could ultimately result in a lesser output of fruit bodies. Rice husk, according to Kumar et al. (2009), contains about 15-20% hemicellulose, 20-25% lignin and 35-40% cellulose. While there are 31-33% hemicellulose, 40–44% cellulose, and 3-5% lignin in corn cobs (Wang et al., 2011). One of the finest substrates for growing oyster mushrooms was cellulose, which has a high organic matter content (Pant et al., 2006). High lignin and phenolic content substrates inhibited cellulose's activity, whereas low lignin would increase enzyme activity, guaranteeing a higher mushroom yield and biological efficiency. This was further supported by Costa et al. (2023), stating that when rice husk is selected as a substrate, the amount used should not exceed 50% of the volume of the substrate; otherwise, poor production may result from the substrates.

The addition of corncob had a substantial effect on the number of fruiting bodies of oyster mushrooms. Corn cob had the most fruit per flush. According to Muhaeming et al., (2021), if a pinhead grows quickly, many fruit bodies will also form since each pinhead that produces a fruit body takes nutrients from the developing media. Furthermore, Chukwurah et al. (2013), forwarded that mixture, type, or usage of one or more agricultural wastes in the preparation of the farm substrates also affected the mushroom fruiting bodies' performance. Corncobs with productive fruiting bodies yielded more, which may have been caused by the substrate's cellulose, hemicellulose and lignin content (Vetayasupron, 2007).

Dhakal et al. (2020) revealed that sawdust is not effective as corn cob as substrate from oyster mushroom production when it comes to mushroom development and yield. Advised to use corn cob substrate than sawdust.

The biological efficiency, calculated as the weight of fresh mushroom fruiting bodies divided by the weight of dry substrates and expressed as a percentage, shows that 100% corncob achieved the highest efficiency at 24%. This was followed by 25% rice husk + 75% corncob with 12%, and 50% rice husk + 50% corncob with 11%, which were comparable to each other. The control, 100% sawdust, had a significantly lower biological efficiency at 7%, indicating poorer performance compared to the other treatments. From the overall result of biological efficiency reveals that corncob (24%) yielded better than other substrates which is rice husk and lowest in sawdust which agrees with results of Dhakal et al. (2020) 100% corn cob had a greater biological efficiency of 91.21% compared to 100% sawdust, which had 85.69%, when the biological efficiency was determined against the dry weight of each substrate; nevertheless, the difference was not statistically significant.

One limitation of the study is that the results are influenced by the specific characteristics of the substrates used, such as their physical properties and chemical composition, which may vary between sources and batches. For example, the observed performance of 100% corncob and its superiority in growth and biological efficiency could be attributed to its optimal lignin, hemicellulose, and cellulose ratios, which may not be consistent across different corncob sources. Similarly, the poor performance of sawdust and the less effective mixtures of rice husk with corncob might reflect limitations inherent to these substrates rather than a generalizable trend. Variations in the substrate's quality, such as differences in nutrient content or microbial contamination, could affect the outcomes and their applicability to different growing conditions or environments. Additionally, the study's findings might not be fully representative of commercial-scale production due to the controlled experimental conditions, which may not account for real-world variability.

CONCLUSION

There is a significant difference in the growth and yield of oyster mushroom applied with different ratios of rice husk and corncob substrate. The oyster mushroom grown on 100% corncob as substrate is efficient to shorten the days to full inoculation and days to first flushing. Consequently, it also improved the yield of oyster mushroom in terms of weight of oyster mushroom, number of fruits per flush, and biological efficiency.

Based on the study's findings, it is recommended to use 100% corncob as the primary substrate for optimal growth and yield of oyster mushrooms, given its superior performance in terms of biological efficiency and development speed. Additionally, experimenting with substrate combinations, such as 25% rice husk + 75% corncob or 50% rice husk + 50% corncob, can offer a balance of growth rate and yield, depending on specific production needs. The use of 100% sawdust should be minimized, as it demonstrated the lowest performance across key metrics. Further research is needed to explore the impact of different substrate sources and their qualities on mushroom production, and to test these findings in commercial-scale settings. Additionally, optimizing substrate ratios and exploring alternative additives could enhance both growth and nutritional quality of the mushrooms.

REFERENCES

Adjapong, A. O., Ansah, K. D., Angfaarabung, F., & Sintim, H. O. (2015). Maize residue as a viable substrate for farm scale cultivation of oyster mushroom (Pleurotus ostreatus). *Advances in Agriculture*, *2015*, 1–6. https://doi.org/10.1155/2015/213251

Amin, S. M., Rahman, M. M., Hossain, M. M., Haque, M. M., & Sarker, N. C. (2007). Effect of different substrates on the growth and yield of five selected oyster mushrooms. *Bangladesh J. Mushroom*, *1*(2), 21-25 https://doi.gov/0.9790/2380-07233846

Chukwurah, N. F., Eze, S. C., Chiejina, N. V., Onyeonagu, C. C., Okezie, C. E. A., Ugwuoke, K. I., ... & Nkwonta, C. G. (2013). Correlation of stipe length, pileus width and stipe girth of oyster mushroom (Pleurotus ostreatus) grown in different farm substrates. *Journal of Agricultural Biotechnology and Sustainable Development*, *5*(3), 54-60. https://doi.org/10.5897/jabsd2013.0197

Costa, A. F. P., Steffen, G. P. K., Steffen, R. B., Portela, V. O., Santana, N. A., dos Santos Richards, N. S. P., & Jacques, R. J. S. (2023). The use of rice husk in the substrate composition increases Pleurotus ostreatus mushroom production and quality. *Scientia Horticulturae*, *321*, 112372. https://doi.gov/10.1016/j.scienta.2023.112372

Decena, O.M.W., & Del Rosario, A. B. (2022). Growth and yield of black oyster mushroom *(Pleurotus ostreatus)* on combined coconut sawdust and rice straw as lignocellulosic materials. *AGRIKULTURA CBSUA Research and Innovation Journal*. https://w3.cbsua.edu.ph/journal_articles3/growth-and-yield-of-black-oyster-mushroom-pleurotus-ostreatus-on-combined-coconut-sawdust-and-rice-straw-as-lignocellulosic-materials/

Dhakal, P., Pokhrel, A., Bista, A., Shah, K., Acharya, B., & Shrestha, J. (2020). Growth and yield performance of oyster mushroom (Pleurotus ostreatus) on different substrates. *Agriways*, *08*(01), 1–8. https://doi.org/10.38112/agw.2020.v08i01.001

Elsisura, I. B., & Figueroa, M. A. G. (2022). Growth and yield performance of oyster mushroom cultivated in combined cassava peels, coconut residue and coffee waste substrates. *American Journal of Environment and Climate*, *1*(1), 1-11 https://doi.gov/10.54536/ajec.v1i1.206

Erlinda, C., Prasetyaningsih, A., & Madyaningrana, K. (2021). Pengaruh Pengomposan Ampas Tebu Sebagai Media Alternatif dan Pengaruhnya Terhadap Produktivitas Jamur Tiram Putih (Pleurotus ostreatus). *LenteraBio Berkala Ilmiah Biologi*, *11*(1), 161–173. https://doi.org/10.26740/lenterabio.v11n1.p161-173

Hultberg, M., Asp, H., Bergstrand, K. J., & Golovko, O. (2023). Production of oyster mushroom (Pleurotus ostreatus) on sawdust supplemented with anaerobic digestate. *Waste Management*, 155, 1-7. https://doi.gov/10.1016/j.wasman.2022.10.025

Khan, M.W., Ali, M.A. Khan, N.A., Rehman, A., and Jave, N. (2013). Effect of different levels of lime and pH on mycelial growth and production efficiency of oyster mushroom (Pleurotus spp.), *Pakistan Journal of Botany*, 45(1), 297-302. http://142.54.178.187:9060/xmlui/handle/123456789/15775

Kumar P, Barret D, Delwiche M, Stroeve P. (2009). Methods of Pretreatment of Lignocellulosic Biomass for Efficient Hydrolysis and Biofuel Production. *Industrial & Engineering Chemistry Research*. 48:3713-3729 https://doi.gov/10.1021/ie801542g

Muchsin A Y, Murdiono W E and Maghfoer M D (2017). Pengaruh Penambahan Sekam Padi dan Bekatul terhadap Pertumbuhan dan Hasil Jamur Tiram Putih (Pleurotus ostreatus) Plantropica *J. Agric. Sci.* 2 30–8. https://doi.org/10.25047/agropross.2020.6

Muhaeming, M., Jamilah, J., & Zulkarnaim, Z. (2021). Pengaruh penambahan serbuk jagung pada komposisi media tanam terhadap pertumbuhan miselium bibit F1 jamur tiram putih (Pleurotus ostreatus). *BIOMA Jurnal Ilmiah Biologi*, *10*(2), 158–170. https://doi.org/10.26877/bioma.v10i2.7429

Pant, D., Reddy, U.G. & Adholeya, A. Cultivation of oyster mushrooms on wheat straw and bagasse substrate amended with distillery effluent. *World J Microbiol Biotechnol* 22, 267–275 (2006). https://doi.org/10.1007/s11274-005-9031-2

Rambey, R., Matondang, G. P. N., & Siregar, E. B. M. (2018). Growth and productivity of mushroom oyster (Pleurotus ostreatus) on mixed planting media of cocopeat with sawdust. *IOP Conference Series Earth and Environmental Science*, *209*, 012035. https://doi.org/10.1088/1755-1315/209/1/012035

Rambey, R., Sitepu, I. D. B., & Siregar, E. B. M. (2019). Productivity of oyster mushrooms (Pleurotus ostreatus) on media corncobs mixed with sawdust. *IOP Conference Series Earth and Environmental Science*, 260(1), 012076. https://doi.org/10.1088/1755-1315/260/1/012076

Samuel, A. A., & Eugene, T. L. (2012). Growth performance and yield of oyster mushroom (Pleurotus ostreatus) on different substrates composition in Buea South West Cameroon. *Science Journal of Biochemistry*, *2012*. https://www.sjpub.org/sjbch/abstract/sjbch-139.html

Sánchez, C. (2009). Cultivation of Pleurotus ostreatus and other edible mushrooms. *Applied Microbiology and Biotechnology*, *85*(5), 1321–1337. https://doi.org/10.1007/s00253-009-2343-7

Sopit Vetayasuporn. (2006). Liginocellulosic materials as a possible substrate for pleurotus ostreatus (Fr.) Kummer cultivation. *Journal of Agronomy*, *6*(1), 167–170. https://doi.org/10.3923/ja.2007.167.170

Tesfaw, A., Tadesse, A., & Kiros, G. (2015). Optimization of oyster (*Pleurotus ostreatus*) mushroom cultivation using locally available substrates and materials in Debre Berhan, Ethiopia. *Journal of Applied Biology & Biotechnology*. https://doi.org/10.7324/jabb.2015.3103

Wang, L., Brennan, M. A., Guan, W., Liu, J., Zhao, H., & Brennan, C. S. (2021). Edible mushrooms dietary fibre and antioxidants: Effects on glycaemic load manipulation and their correlations pre-and post-simulated in vitro digestion. *Food Chemistry*, *351*, 129320. https://doi.org/10.1016/j.foodchem.2021.129320

Yu, H., Zhang, D., Zhang, L., Li, Q., Song, C., Shang, X., Bao, D., Tan, Q., Chen, H., & Lv, B. (2021). Corncob as a substrate for the cultivation of *Lentinula edodes*. *Waste and Biomass Valorization*, *13*(2), 929–939. https://doi.org/10.1007/s12649-021-01575-y

Zhang, Y., Ghaly, A. E., & Li, B. (2012). Physical properties of corn residues. American *Journal of Biochemistry and Biotechnology*, 8(2), 44-53 https://doi.org/10.3844/ajbbsp.2012.44.53