RESEARCH ON UTILIZING COFFEE GROUNDS AS A SUBSTRATE FOR CULTIVATING GREY OYSTER MUSHROOMS (PLEUROTUS SAJOR-CAJU) IN URBAN AREAS

Nguyen Thi Thanh Thao[(1)], Nguyen Thi Ngoc[(1)], Nguyen Hoang Tien[(1)], Pham Le Minh Thien[(1)], Pham Anh Thu[(1)], Nguyen Huu Vinh[(1)]

(1) Thu Dau Mot University
Corresponding author: thanhthao@tdmu.edu.vn

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Abstract

Urban agriculture is a highly concerning issue during the period of rapid urbanization in Vietnam. Research aims to propose a cultivation process for cultivating oyster mushrooms, utilizing coffee grounds from coffee businesses as a resource. This approach promotes circular economy principles, generating economic benefits for households while protecting the environment and being suitable for urban areas. The study conducted experiments on Grey oyster mushrooms using different mixtures of coffee grounds and rubber wood sawdust at the following ratios: 0%, 25%, 50%, 75%, and 100% coffee grounds/rubber wood sawdust, filled into bags with a weight of 1.2kg. The research results showed that disease infection rates were mild in the 0% and 25% mixture ratios, while the remaining ratios exhibited moderate to severe infection levels. The highest mushroom yield was observed in the mixture ratio of 25% coffee grounds, with an average number of mushroom ears per bag reaching 29.7 grams/bag, the dry weight is 63.8 grams/bag, with an average size ranging from 3 to 14cm and a moisture content of 79.5%. The fastest colonization speed on the substrate is achieved by the 25%, 50% coffee grounds blend, which fully colonizes the bag in a period of 25 to 35 days, the shortest time compared to the 75% and 100% coffee grounds blends, which take 40 to 45 days. The experimental results show that the 25% coffee grounds: 75% rubber sawdust blend is suitable for urban mushroom cultivation models and can be expanded on a large-scale farm, contributing to minimizing environmental pollution, utilizing limited urban land area, and providing high economic efficiency.

Keywords: circular economy, coffee ground, Grey oyster mushrooms, urban agriculture

1. Introduction

The Grey oyster mushrooms is an edible mushroom belonging to the Pleurotaceae family, with the scientific name Pleurotus Sajor-caju. It is a clean vegetable that offers a delicious flavor and is commonly used in everyday dishes. Oyster mushrooms contain many nutrients that are beneficial to health, helping to nourish the body, benefit the digestive system, and provide a relatively high protein content. They also have antibacterial effects, can reduce cholesterol, improve health, aid in treating diabetes, act as antioxidants, and help prevent many diseases in life (Thang and Minh., 2005). However, mushrooms are often sold on the market at a high price and are frequently mixed with fake, poor-quality mushrooms (Vuon rau pho, 2023). To create a source of mushroom raw materials, ensuring adequate nutrients suitable for cultivation conditions in urban areas, many studies have been conducted (Tien, 2015; Quynh, 2018; Hung, 2022; Quynh, 2019).

Coffee is a familiar drink available everywhere in the country, from modern, bustling cafes to small, simple shops tucked around the corner or on the sidewalk. With the Vietnamese culture of enjoying a cup of coffee alone or with friends, the demand for coffee products and beverages is increasing. The coffee business is growing, especially coffee shop businesses, which are currently being chosen as the first start-up target for investors. Therefore, the amount of coffee grounds discharged daily at coffee shops is large. A small amount is used in cosmetics and as fertilizer for ornamental plants and vegetables, while the rest is usually disposed of as waste (Huyen, 2021). The amount of coffee grounds poses a potential source of environmental and soil pollution because coffee grounds contain a lot of mold. There have been many studies using coffee grounds as fertilizer, growing substrate for mushrooms (Shanegenziuk, 2011), and applications in the cosmetics industry (Shanegenziuk, 2011). However, there are no studies that show the value of a suitable model for the urban agricultural sector.

Currently, the urbanization rate of Binh Duong province is very fast, reaching 82% (Hiep and Xuan, 2016). Situated centrally in the key economic region of the South, Binh Duong holds great development potential, with significant infrastructure investment and the construction of many industrial zones. This has attracted a large number of qualified human resources, leading to high demand for housing and resulting in the agricultural land area in the city becoming increasingly narrow. It is necessary to find an agricultural production model, especially in urban areas, that takes advantage of small land areas to bring about economic efficiency and employment opportunities for people in the city.

The research group has utilized waste from the entertainment service industry, specifically coffee grounds discarded after brewing from coffee shops, to carry out the topic: "Research on utilizing coffee grounds as a substrate for cultivating Grey oyster mushrooms (*Pleurotus sajor-caju*) in urban areas." The objective is to find solutions to diversify urban agricultural products, apply circular economy principles, improve the condition of land for agriculture that is gradually being replaced by urbanization, harness wasted resources to enhance environmental and community regeneration, and minimize environmental pollution.

2. Research objectives and Methods

2.1. Research objectives

To determine the blending formula for the substrate using coffee grounds, evaluate the yield of Grey oyster mushrooms in different experimental setups, and propose a mushroom cultivation process in urban areas that brings about economic and environmental benefits.

2.2. Research methods

2.2.1 Materials and experimental conditions

Grey oyster mushrooms (*Pleurotus Sajor - caju*) were obtained from the Mushroom Agricultural Company Limited.

The coffee grounds were collected from Xanh2Go coffee shops located in Thu Dau Mot town, Binh Duong province.

The coffee used meets food safety standards, with no preservatives or other additives. Sawdust from rubber wood, which has been composted, was provided by the Institute of Biotechnology and Environmental Protection Research, Ho Chi Minh City University of Agriculture and Forestry.

Additionally, the BioTech-BonMua autoclave, heat-resistant mushroom spawn bags, sealing caps, cotton wool, alcohol, rubber bands, tarpaulin, weighing scale, mushroom plug spawn, and newspaper were used in this study.

2.2.2 Experimental conditions

Laboratory area: 2m × 3m = 6m^2 (utilizing an empty, well-ventilated room in an urban residential area).

The mushroom cultivation process and experiments were conducted in the urban area of Chanh Nghia ward, Thu Dau Mot city, Binh Duong province. The room temperature ranged from 22 to 30°C, with humidity levels between 55% and 90% (humidity was maintained for optimal mushroom growth by spraying fine mist four times a day after the mushrooms have developed). The room was kept partially dark by closing the door to minimize light. Air circulation in the mushroom room was maintained using an exhaust fan while preventing strong or gusty winds.

2.2.3 Experimental design and mushroom cultivation process

Because the goal of this study's cyclical economic model is to facilitate adoption by urban households and small coffee shops, the experimental conditions were conducted naturally. Room temperature was maintained, and the mushroom cultivation room was kept well-ventilated. Humidity was maintained for optimal mushroom growth by spraying fine mist four times a day after the mushrooms have developed.

The research Team selected four experimental treatments with different ratios of sawdust and coffee grounds (1/4, 1/2, 3/4, and 4/4) and one control treatment without coffee grounds to study. These ratios were chosen to facilitate easy observation and monitoring, aiming to identify a suitable substrate mixing ratio for mushroom cultivation. This choice also aims to simplify the adoption of the model by the public, as the substrate mixing process during cultivation becomes straightforward.

a. Experimental arrangement: The experiments were arranged in a completely randomized block design, with 5 treatment groups consisting of different ratios of sawdust and coffee grounds: 0%, 25%, 50%, 75%, and 100% coffee grounds. Each treatment group consisted of 5 substrate bags with 3 replications, resulting in a total of 75 substrate bags (experimental units).

TABLE 1. Experimental treatments for Grey oyster mushrooms cultivation

Experimental treatments	Number of substrates (bag)	Repetitions	Coffee grounds (%)	Rubber sawdust (%)
X0	5	3	0	100
X25	5	3	25	75
X50	5	3	50	50
X75	5	3	75	25
X100	5	3	100	0

(The experiment is set up in urban homes in Thu Dau Mot town, Binh Duong province. The specimen bags are placed on stacked shelves and are separated into different areas for each experiment).

b. The process of cultivating The Grey oyster mushrooms: This study applies a method that has been transferred from the Binh Duong Science and Technology Application Center - Department of Science and Technology of Binh Duong Province. This method is also commonly used for mushroom cultivation among the locals.

c. Data processing method: The experiments were conducted with three repetitions, and the average values were taken and compared. The data was calculated using Microsoft Excel software.

3. Results and Discussion

3.1 Research on infection rates

During the monitoring process, it was discovered that the substrate for mushroom cultivation (mushroom embryo) was contaminated with Pink mold (*Corticium salmonicolor*), which is commonly found in coffee grounds. The results indicated that the highest incidence of Pink mold was observed 10 days after mushroom cultivation. Substrates containing higher proportions of coffee grounds exhibited a greater occurrence of Pink mold, with the highest prevalence noted in substrates containing 75% and 100% coffee grounds. Furthermore, airborne contaminants such as green mold (*Aspergillus*) and black mold (*Colletotrichum Cofeanum*) were identified as thriving in the mushroom embryo due to suitable moisture and temperature conditions, in addition to being present in coffee grounds.

The results from Table 2 indicate that all experimental treatments were mostly infected. The mixed treatments with 0% coffee grounds and 25% coffee grounds had the lowest incidence of disease, making them suitable for large-scale cultivation and fungal development. In contrast, the fermentation mixtures with 50%, 75%, and 100% coffee grounds had a higher incidence of disease in the Grey oyster mushrooms embryo compared to the 0% and 25% coffee grounds mixtures treatments. This suggests that as the proportion of coffee in the mushroom embryo increased, the incidence of disease also increased.

TABLE 2. Rate of infection on Grey oyster mushrooms

Experimental treatments	Repetitions	No infection	Mild infection	Moderate infection	Severe infection
X0	Rep 1		X		
	Rep 2		X		
	Rep 3	X			
X25	Rep 1		X		
	Rep 2		X		
	Rep 3		X		
X50	Rep 1				X
	Rep 2				X
	Rep 3			X	
X75	Rep 1			X	
	Rep 2				X
	Rep 3				X
X100	Rep 1				X
	Rep 2				X
	Rep 3				X

Note:
- *No infection: The mushroom bags are not infected with any other fungi (<5%).*
- *Mild infection: The incidence of disease ranges from 5-30% of the mushroom embryo area.*
- *Moderate infection: The incidence of disease ranges from 30-60% of the mushroom embryo area.*
- *Severe infection: The incidence of disease is above 60% of the mushroom embryo area.*

3.2 Development time of hyphae

The hyphae growth during the period of 10-20 days indicates a slow development process, with hyphae strands extending from the mouth of the bag to nearly 50% of the mushroom embryos, while the mushroom rays grow on thin filaments. The rate of hyphae growth on treatments containing 0%, 25%, and 50% coffee grounds was the fastest, covering the mushroom bag completely within 25-35 days, while the shortest hyphae growth time on substrates containing 75% and 100% coffee grounds treatments was 40-45 days. This is attributed to the mushroom embryos being infected with pink and black molds, resulting in slower spreading speed, and the mushroom embryo bags being tight and less breathable compared to treatments containing sawdust, thus contributing to the slower spreading speed of the Grey oyster mushrooms.

TABLE 3. The rate of hyphae growth on the mushroom embryo (%)

Date	The rate of hyphae growth on the mushroom embryo (%)				
	X0	X25	X50	X75	X100
9	25%	25%	0%	0%	0%
12	50%	25%	25%	0%	0%
15	50%	50%	25%	25%	0%
18	75%	50%	50%	25%	25%

21	75%	75%	50%	25%	25%
24	100%	75%	50%	50%	25%
27	100%	75%	75%	50%	50%
30	100%	100%	75%	50%	50%
33	100%	100%	75%	75%	50%
36	100%	100%	100%	75%	75%
39	100%	100%	100%	75%	75%
42	100%	100%	100%	100%	75%
45	100%	100%	100%	100%	100%

The time and rate of hyphae growth of Grey oyster mushrooms, as shown in Table 3, indicate noticeable development during the hyphae colonization period. The hyphae growth rate gradually decreases with an increasing percentage of coffee grounds in the substrate mixture.

3.3 Mushroom yield results

TABLE 4. Mushroom yield results of the treatments

Experimental treatments	Quantity (ear)	Fresh weight (g)	Dry weight (g)	Size (cm)	Humidity (%)
X0	25,7	227,8	45,6	3-12	80,0
X25	29,7	311,4	63,8	3-14	79,5
X50	12,5	196,5	38,1	2-12	80,6
X75	8,8	75,4	22,7	2-10	69,9
X100	8,3	76,5	17,7	3-13	76,9
Average	17,0	177,5	37,6		

** Note: Harvest time from June 3, 2023 to September 30, 2023.*

The experimental results indicate that the 25% coffee grounds mixture has the highest mushroom yield, averaging 29,7 ears with a fresh weight of 311,4 grams, dried weight of 63,8 grams, an average size of 3-14 cm, and a moisture content of 79,5%. The yield gradually decreases as the percentage of coffee grounds increases, with the lowest yield observed in the 100% coffee grounds mixture, producing 8.3 mushrooms, 76,5 grams fresh weight, 17,7 grams dried weight, with a size of 3-13 cm, and a mushroom moisture content of 76,9%. Therefore, incorporating the 25% and 50% coffee grounds mixtures into urban mushroom cultivation models and potentially expanding to large-scale farms can contribute to minimizing environmental pollution, reducing soil degradation, and achieving high economic efficiency with low investment costs.

TABLE 5. Yield results of Grey oyster mushrooms

Experimental treatments	Fresh weight (g/bag)	Dry weight (g/bag)	Common yield (*) (g/bag)
X0	227,8	45,6	160
X25	311,4	63,8	160
X50	196,5	38,1	160
X75	75,4	22,7	160
X100	76,5	17,7	160

(*) Common yield: Average yield of gray oyster mushrooms (g/bag) grown at Tho Vuc Farm, Xuan Bac Commune, Xuan Loc District, Dong Nai Province.

Comparing the average yield of Grey oyster mushrooms cultivated at Tho Vuc Farm, Xuan Bac Commune, Xuan Loc District, Dong Nai Province, as shown in Table 5 and Figure 1, the mushroom yields in the X0, X25, and X50 treatments are higher than the average yield obtained from farm cultivation. On the other hand, the X75 and X100 treatments have yields that are less than half of the farm yield.

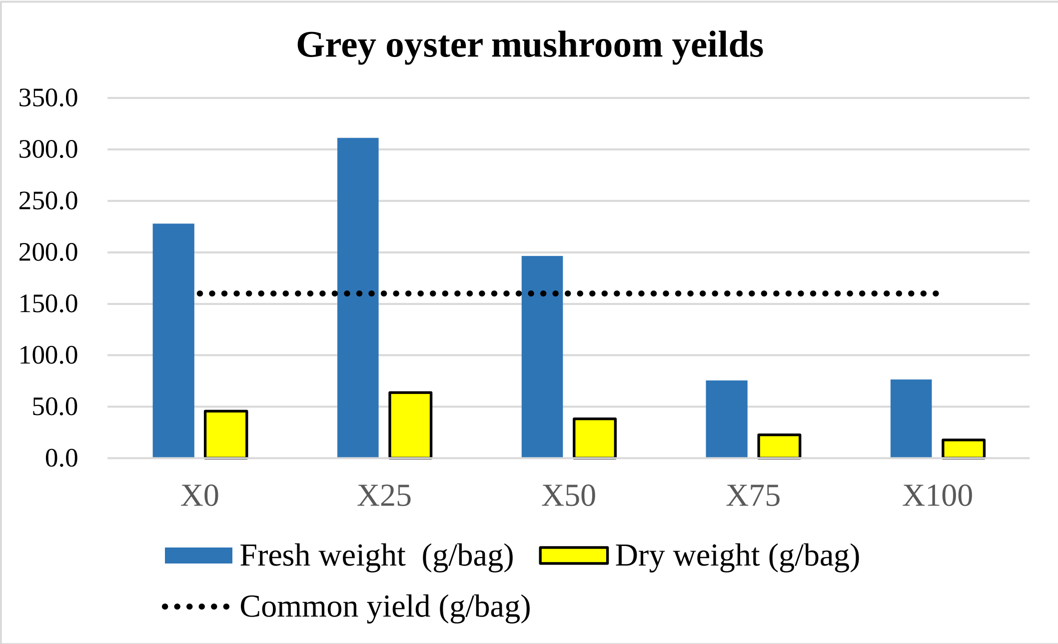

Figure 1. Mushroom yield (grams)

The results from Figure 1 demonstrate that the X25 treatment has the highest average fresh mushroom weight, exceeding 300 grams per bag, while the lowest fresh mushroom weight is observed in the X75 treatment. The rate of dried mushroom weight is highest in the X25 treatment, with over 50 grams, and lowest in the X100 treatment. These results indicate that the X25 treatment (with a 25% coffee grounds mixture) is the most suitable and effective treatment in terms of yield and quality among the experimental treatments. It can be recommended as a mushroom cultivation model that promotes environmental protection, utilizes waste from the coffee service industry, saves land for agricultural production in urban areas, and contributes to the development of urban agriculture models, ultimately creating green cities.

3.4 Economic benefits

The results of the economic analysis of the experimental mushroom cultivation model, suitable for urban conditions and small-scale farms in the market, are presented in Table 6. The research findings indicate that with a space of 6 m^2, a profit of 8.100.000 VND per year can be obtained. In comparison, a mushroom farm with a space of 60 m^2 can generate a profit of 14.500.000 VND per year. Therefore, the calculated profit from the research project is 675.000 VND per month, while the mushroom farm achieves a profit of 1.208.333 VND per month. The analysis results demonstrate that the urban mushroom cultivation model has provided effective income for urban households and small coffee businesses. It not only brings economic benefits but also allows for space-saving cultivation with a relatively small land area.

TABLE 6. Analyze the economic efficiency of the experimental treatments

Content for an area of 6m2 (Cost for 200 embryo bags)	**Quantity**	**Product price (VND)**	**Costs (VND)**	**Compare with Mushroom Production Farm** (Area: 60 m^2 (10×6))	
Planting house (take advantage of space): Empty room, warehouse, warehouse corner... Usable area: 2×3=6m^2 (can grow 300-500 embryo bags).	1	-	-		30.000.000
Assembled shelf (can be placed on the floor or hung on a truss: reduces costs): (5 floors × 150cm × 40cm) - Long-term	3 prs	1.200.000	3.600.000	Hang the bag	1.500.000

use.					
Experimental materials: +Plastic bags size 25×35cm;	3 kg	65.000	195.000		
+Cotton balls, clean newspaper and rubber bands.	1	20.000	20.000		
Bottle neck size 34mm: 1kg has about 300 pieces (no caps to reduce costs)	1	45.000	45.000	60 kg cap	1.800.000
Mushroom spawn: 1 bag of seed can produce 50-100 bags.	4	20.000	80.000		
mushroom embryo bags for a 3-6 month growing process: 200kg sawdust (use 3-6 months): 200kg needed for 200 embryo bags;	2	50.000	100.000	10.000 embryo bags	27.000.000
Coffee grounds: used from coffee shops: 100kg for 200 bags of 25% coffee beans (use for 3-6 months)	100	-	-		
Cost of mushroom culture tool: 2 alcohol lamps: 2×30.000 VND/piece; tweezers 30.000 VND/piece; 90 degree alcohol: 15.000 VND/bottle - Long-term use	1	135.000	135.000		
Raw material transportation costs (trip)	1	400.000	400.000	Trips	3.000.000
Total first cost for 200 embryo bags/6 m^2			**4.575.000**	**Total cost (10.000 bags/60 m^2/year)**	**63.300.000**
Total cost for the first time for 01 embryo bag.			**22.875**		
Cost for crops 2 and 3 (Investment in 3 crops/year)			840.000		
Total investment in the year (3 crops): only calculated for 200 embryo bags, the number of embryo bags can increase and income will decrease.			6.255.000		
Cost for 01 embryo sac/ calculated over 01 year.			10.425		6.330
PROFIT					
Highest yield (X25 of 25% coffee grounds): 0.3 kg/bag × 600 bags (3 harvesting periods/year)/ 6m^2 of land.	180	50.000	9.000.000	Yield: 1.600kg x 25.000 VND	40.000.000
Profit: (3.600.000 VND/6m^2/4 months)			8.100.000	Profit: (-31.800.000) VND/60 m^2/4 months	14.500.000
Profit/month (VND)			**675.000**		**1.208.333**

3.5 The benefits of environmental protection and urban land management

This research, in addition to economic efficiency and applying circular economic production, also aims to take into account environmental benefits, apply clean urban agricultural production models, utilize high technology, manage land effectively, and promote environmental protection in urban areas.

TABLE 7. The benefits of environmental protection and urban land management

The benefits of environmental protection and urban land management	Model of mushroom production in urban areas	Mushroom production model on the farm
Bag of mushroom embryo waste after planting	200 waste embryo bags (use for growing clean vegetables or ornamental flowers)	For sale: 6.000.000 VND
Waste treatment	Reduce 300 kg of coffee grounds waste/year/6m^2 of land.	
Income on a small urban land area, taking advantage of urban space to increase income or provide food for the family	675.000 VND/6m^2	1.208.333 VND/60m^2

The analysis results in Table 7 show that the research has reduced the amount of waste by about 300 kg of coffee grounds per year, taking advantage of 200 bags of embryos for a 4-month crop per 6m2 of waste to continue growing straw mushrooms, clean vegetables, or ornamental flowers. Calculated profit reaches 675.000 VND per 6m^2. Compared to a farm that produces edible mushrooms, which earns 14.500.000 VND per year on 60 m^2, with an average monthly profit of over 1.200.000 VND, the results demonstrate that the experimental model is economically effective compared to current edible mushroom farms.

In addition, the experimental model of using coffee grounds to grow mushrooms also yields environmental benefits, aids in urban land management, and applies circular economic production models in urban agriculture, contributing to waste reduction discharged into the environment, utilizing expanded agricultural production areas, and creating job opportunities in urban areas.

4. Conclusions

In the X25 experimental formulations, with a ratio of 25% coffee grounds to 75% sawdust, the average number of mushroom caps reached 29.7 per bag, with an average fresh weight of 311 grams per bag. This formulation yielded the highest productivity, while the lowest productivity was observed in the 100% coffee grounds formulation, with an average of 8.3 mushrooms, and an average fresh weight of 74.6 grams per bag. Therefore, using only coffee grounds for mushroom cultivation is not effective. Based on these results, it is suggested to adopt a mushroom production model in urban areas with a 25% coffee grounds mixture in the substrate. This model is suitable, efficient, and can be tested for scaling up to larger farms, contributing to the reduction of environmental pollution.

The cultivation process should focus on sterilizing the substrate, as coffee grounds are prone to fungal contamination. It is recommended to use 10 cm diameter glass bottles, which facilitate the easy growth of mushrooms and convenient harvesting. Further experiments should be conducted on various edible mushroom species to diversify the production materials. This will also allow for comparisons and the selection of suitable mushroom species for urban agricultural production conditions, increasing economic efficiency, and reducing environmental pollution.

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