

EFFECTS OF DIFFERENT NUTRIENT MEDIA ON THE GROWTH AND DEVELOPMENT OF LEVEL III SPAWN OF THE GOLDEN OYSTER MUSHROOM (*PLEUROTUS CITRINOPILEATUS*)

Nguyen Duc Hai^{1*}, Nguyen Chung Ha², Pham Thi Mai Huong¹,
Ha Thi Dung¹, Trinh Thi Hai¹, Vu Thi Cuong¹, Vu Dinh Giap¹,
Nguyen The Huu¹, Nguyen Manh Ha¹, Do Thi Hanh¹

DOI: <https://doi.org/10.57001/huih5804.2026.141>

ABSTRACT

The golden oyster mushroom (*Pleurotus citrinopileatus*) is an edible mushroom with high nutritional value, rich in protein, vitamins, and minerals, and has potential applications in medicinal and functional foods. Research and refinement of the production process are crucial for improving the yield and quality of commercial mushrooms. This study aimed to evaluate the effects of different nutrient media on the growth and development of grade III spawn (*P. citrinopileatus*). Five nutrient media formulations were developed with different carbon, nitrogen, and mineral sources. The growth rate and morphological characteristics of the mycelium were monitored for 21 days under a temperature range of 24 - 28°C. The results showed that formulation M4 (40.5% rice grain, 40.5% sawdust, 3% maize bran, 15% wheat bran, and 1% CaCO₃) resulted in faster mycelial growth, with dense, white, and uniformly distributed mycelium that firmly adhered to the substrate, reaching a mean mycelial length of 13.52cm. This research contributes to determining the optimal medium formula for the third stage of mushroom spawn production, laying the groundwork for large-scale propagation and improving the efficiency of cultivating golden oyster mushrooms.

Keywords: Golden oyster mushroom, propagation, mushroom cultivation, mycelium.

¹Hanoi University of Industry, Vietnam

²Bac Ninh Provincial Party Committee - Organization Commission, Vietnam

*Email: haind1@hai.edu.vn

Received: 15/3/2026

Revised: 15/5/2026

Accepted: 25/5/2026

1. INTRODUCTION

Vietnam is characterized by a tropical monsoon climate, which provides favorable conditions for the high diversity and abundance of biological resources, particularly fungi, including edible and medicinal mushrooms. These organisms are not only recognized as nutrient-dense food sources but have also been extensively reported to contain bioactive compounds with diverse pharmacological properties, thereby playing a significant role in healthcare and the improvement of quality of life. In recent years, edible and medicinal mushrooms have increasingly emerged as promising biological resources, attracting

considerable attention from researchers, industry stakeholders, and local communities for their exploitation and sustainable development.

P. citrinopileatus is recognized as a nutritionally and pharmacologically valuable mushroom species. It is characterized by desirable sensory attributes and a high nutritional profile, being rich in protein and dietary fiber while maintaining low lipid and caloric contents. This species contains a full complement of twenty amino acids and essential minerals required for human health, and is particularly notable for its low fat content, making it suitable for healthy dietary regimens. Specifically, the

chemical composition of *P. citrinopileatus* comprises 22.10% protein, 1.32% lipid, and 20.78% dietary fiber, along with various minerals, among which potassium accounts for 2.28%, followed by copper, zinc, and iron at lower concentrations ranging from 0.0002% to 0.01%. In addition, eight essential amino acids have been identified in *P. citrinopileatus*, with concentrations in decreasing order as follows: leucine > valine > threonine > lysine > phenylalanine > isoleucine > methionine > tryptophan. Another non-essential amino acid present at a relatively high proportion (3.07%) is glutamic acid. This mushroom also contains various vitamins, including vitamin B3 (nicotinic acid), vitamin B5 (pantothenic acid), and vitamin B2 (riboflavin). In contrast, vitamin B12 (cyanocobalamin) and vitamin A (retinol) are present in lower amounts, with concentrations ranging from 0.3 to 10 µg/100g. Therefore, *P. citrinopileatus* can be considered a valuable source of micronutrients with potential health benefits [1]. *P. citrinopileatus* is an edible fungus with high nutritional value and a distinctive flavor. After harvesting, it can be processed into a variety of products to extend shelf life and enhance added value. Owing to these characteristics, *P. citrinopileatus* has been increasingly utilized in the development of health-promoting products.

In addition to its role as a nutritious food source with considerable potential, this mushroom has been demonstrated to be rich in antioxidant compounds that can scavenge free radicals responsible for cellular and physiological damage, including polyphenols and flavonoids. In 2019, Chaomin Yin et al. reported that the total polyphenol content in *P. citrinopileatus* ranged from 0.188 to 2.677mg GAE/g dry weight, while flavonoid content ranged from 0.137 to 0.445mg QE/g dry weight, depending on the extraction solvent. Using High-performance liquid chromatography (HPLC), the study identified catechin and quercetin as the major polyphenolic compounds in the mushroom extracts. In addition, gallic acid, ferulic acid, vanillic acid, and chlorogenic acid were detected at lower concentrations [2]. Phenolic compounds have been widely reported to exhibit strong antioxidant activity, along with anticancer, anti-atherosclerotic, antimicrobial, and anti-inflammatory effects [3, 4]. Notably, the antioxidant activity of *P. citrinopileatus* has been reported to be approximately threefold higher than that of *Pleurotus salmoneostramineus* and *Pleurotus ostreatus* [5].

Catechin is a phenolic compound that has been demonstrated to possess anti-inflammatory and

antioxidant activities and has been applied in the management of various pathological conditions. It also shows potential in modulating gut microbiota, thereby supporting digestive function and reducing the risk of related diseases [6]. In addition, quercetin is another phenolic compound that protects the body against reactive oxygen species, thereby enhancing cellular longevity and mitigating the aging process [7]. Therefore, given its considerable polyphenol content, particularly the high levels of catechin and quercetin, the golden oyster mushroom *P. citrinopileatus* exhibits strong potential as a health-promoting food and may be further exploited for functional food and pharmaceutical applications. In mushroom cultivation, spawn quality plays a decisive role in determining yield and fruiting body morphology. Spawn with a uniformly developed, rapidly colonizing, and vigorous mycelial network can shorten the incubation period and improve the adaptability of the fungus during fruiting body formation. Notably, level I spawn, representing the initial stage in the propagation process, is critical for ensuring genetic stability and consistent growth performance.

In mushroom cultivation, spawn production is a critical stage that directly determines yield, fruiting quality, and the overall economic efficiency of commercial production systems. Spawn is commonly propagated through three sequential levels, including mother spawn (grade I), intermediate spawn (grade II), and production spawn (grade III). Among these, grade III spawn serves as the direct inoculum for fruiting substrate cultivation. The quality of grade III spawn is influenced by several factors, including fungal strain characteristics, temperature, moisture content, medium pH, and particularly the nutritional composition of the culture medium.

Previous studies have demonstrated that mineral-supplemented potato dextrose agar (PDA) promoted the fastest mycelial growth, with denser and more highly branched hyphae compared to conventional PDA or coconut-water-supplemented PDA media. Under these conditions, the mycelium completely colonized the agar plate within approximately eight days, indicating that nutrient composition markedly affects the mycelial development of the golden oyster mushroom [8]. The mycelium of *P. citrinopileatus* was reported to grow optimally at 25°C, while fructose at 20gL⁻¹ was identified as the most suitable carbon source for mycelial growth. Peptone supplementation at 4gL⁻¹ was considered the most appropriate nitrogen source for enhancing mycelial

development [9]. In Vietnam, studies on the golden oyster mushroom remain relatively limited, particularly those focusing on the effects of nutritional media on the growth characteristics of grade III spawn. Identifying an appropriate culture medium capable of improving mycelial colonization rate, uniformity, and spawn quality is therefore essential for optimizing spawn production protocols and supporting large-scale commercial cultivation.

Based on these scientific and practical considerations, the present study was conducted to evaluate the effects of different nutrient media on the growth and development of grade III spawn mycelia of *P. citrinopileatus*, with the aim of identifying a suitable medium for the production of high-quality commercial spawn.

2. MATERIALS AND METHODS

2.1. Materials

Secondary culture of *P. citrinopileatus* was prepared by propagating first-generation spawn (level I spawn) on a grain-based medium (rice) in glass bottles. The resulting level II spawn was required to meet the following criteria: the mycelium was pure and free from contamination; the mycelial network was vigorous, uniformly distributed, and fully colonized the substrate within the culture bottles.

2.2. Methods

2.2.1. Evaluation of the effects of nutrient media on the growth and development of level III spawn

Using a sterile inoculation loop, approximately 15 - 16g of level II spawn was transferred from the culture bottle to each level III substrate bag. In this study, level III spawn was propagated on five substrate formulations (M1-M5), whose compositions are presented below (% w/w):

M1 (control): 99% rice grain and 1% CaCO₃.

M2: 81% rice grain, 3% maize bran, 15% wheat bran, and 1% CaCO₃.

M3: 40.5% rice grain, 40.5% corn cob, 3% maize bran, 15% wheat bran, and 1% CaCO₃.

M4: 40.5% rice grain, 40.5% sawdust, 3% maize bran, 15% wheat bran, and 1% CaCO₃.

M5: 27% rice grain, 27% corn cob, 27% sawdust, 3% maize bran, 15% wheat bran, and 1% CaCO₃.

The substrate was then transferred into 0.5kg plastic bags and sterilized by autoclaving at 121°C for 90 minutes. The mycelial growth time was monitored for 21

days, with a temperature of approximately 24 - 28°C until the substrate was completely covered by the fungus [10].

2.2.2. Evaluation of mycelial growth

Assessment of mycelial morphology (color, structure, and density) [11]: Mycelial growth was evaluated visually based on colony color, structure, and density. Satisfactory mycelium was characterized by a white appearance, vigorous growth, straight and evenly branched hyphae, and the absence of contamination. Unsatisfactory mycelium exhibited discoloration (e.g., dark or pale regions), the presence of yellow or brown exudates on the surface, or signs of contamination. In addition, mycelium showing growth arrest, hyphal degeneration, or cell death was also classified as unsatisfactory.

Measurement of mycelial length and growth rate [12]: Mycelial length was measured at 2 - 3 day intervals using a ruler with 1 mm precision. The mycelial growth rate was calculated based on the increase in mycelial length over time.

3. RESULTS AND DISCUSSION

3.1. Morphological changes of level III spawn mycelium over time

Five substrate formulations were established based on previously reported studies [10, 13] to optimize the propagation efficiency of level III spawn. These media were selected for their cost-effectiveness and suitability for large-scale production under local conditions. Level III propagation enables stricter quality control of the mycelium by ensuring that only healthy and vigorously growing cultures are transferred to the subsequent cultivation stage. This step also contributes to improved production efficiency and reduced contamination risks during substrate bag cultivation. In addition, well-developed level III spawn may enhance the resilience of mycelium to adverse conditions, thereby providing technical and economic benefits for mushroom production.

To evaluate the effects of nutrient substrate composition on the mycelial growth of level III spawn, an experiment was conducted using five different substrate formulations (M1-M5). Each treatment consisted of 22 spawn bags and was performed in triplicate. The formulations differed in the proportions of rice grain, corn cob, sawdust, corn bran, and wheat bran. In addition, all treatments were supplemented with CaCO₃ (1%) to stabilize pH and improve conditions for mycelial development. Mycelial growth was determined by



measuring mycelial extension length in three representative bags corresponding to the three experimental replicates for each treatment.

Based on the results presented in Figure 1, after 21 days of incubation, clear differences among the substrate formulations were observed in terms of mycelial colonization rate, mycelial quality, and biological stability. M1 maintained a stable growth rate, with dense, compact, and uniformly distributed white mycelium that firmly adhered to and fully colonized the substrate, with no signs of contamination. Similarly, M4 exhibited optimal development, characterized by bright white, dense, and smooth mycelium with uniform colonization across substrate bags and no detectable contamination. In some samples, the formation of small fruiting bodies at light-exposed areas suggested that the mycelium had reached physiological maturity. In contrast, M2 showed a slower colonization rate, with incomplete substrate coverage and thin, sparsely distributed mycelium with weak adhesion. M3 produced thin, pale mycelium and exhibited contamination by green and yellow molds at the bottom and edges of the bags, negatively affecting mycelial quality. Although M5 showed relatively high substrate colonization, contamination by green mold, particularly at the bottom, compromised overall mycelial quality.

Figure 1. Growth of level III spawn mycelium on different nutrient media after 21 days of incubation

In summary, M1 and M4 supported stable mycelial development that met the criteria for level III spawn. Among the tested formulations, M4 was considered the most optimal, likely due to its balanced aeration and moisture conditions, which facilitated sustained and uniform mycelial growth.

3.2. Effects of nutrient media on the growth and development of level III spawn

Table 1. Length of tertiary mycelium on different nutrient media

Cultivation time (days)	Mycelial length (cm)				
	M1 (Control)	M2	M3	M4	M5
3	4.28 ± 0.18	3.71 ± 0.18	1.71 ± 0.25	4.03 ± 0.18	2.37 ± 0.29
6	6.41 ± 0.19	5.58 ± 0.37	5.03 ± 0.10	5.74 ± 0.26	4.92 ± 0.17
9	9.95 ± 0.07	8.24 ± 0.30	6.92 ± 0.24	7.56 ± 0.30	7.23 ± 0.44
12	11.25 ± 0.28	9.61 ± 0.21	7.73 ± 0.19	9.23 ± 0.36	8.26 ± 0.46

15	12.65 ± 0.23	9.93 ± 0.10	8.77 ± 0.21	10.50 ± 0.31	9.27 ± 0.28
18	13.52 ± 0.03	10.61 ± 0.32	9.73 ± 0.26	13.32 ± 0.18	11.74 ± 0.56
21	13.52 ± 0.03	13.10 ± 0.28	13.42 ± 0.12	13.52 ± 0.12	13.46 ± 0.08

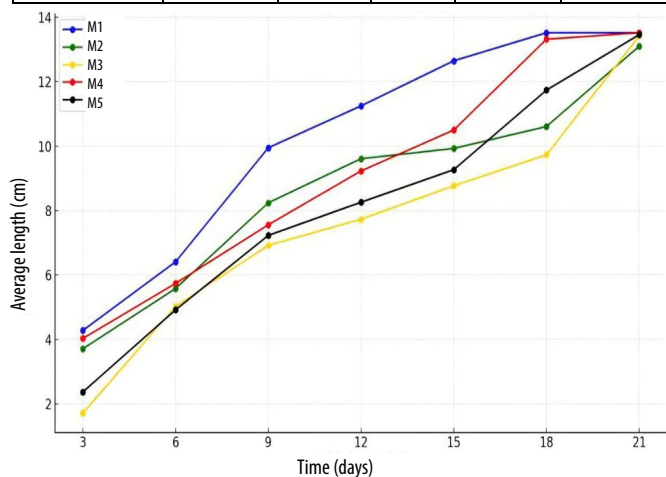


Figure 2. Average mycelial length of level III spawn grown on different nutrient media

The composition and nutrient content of the culture medium are critical determinants of mycelial development during the spawn propagation stage. Mycelial growth is strongly influenced by the characteristics of the substrate; therefore, the selection and appropriate formulation of nutrient sources play a key role in optimizing mycelial colonization rate and overall growth quality of the spawn.

Table 1 and Figure 2 demonstrate that substrate composition significantly affected the mycelial growth of *P. citrinopileatus* during the incubation period. M1 exhibited the fastest mycelial extension and achieved complete colonization (13.52cm) by 18 days. In contrast, M3 showed the slowest growth during the early cultivation stage, likely due to the high lignocellulosic content of corn cob, which is more resistant to fungal degradation. Although mycelial growth in M4 was initially lower than that in M1, rapid development was observed during the later incubation stage, reaching complete colonization by 21 days. Meanwhile, M5 exhibited slower and less uniform mycelial growth throughout most of the cultivation period despite reaching 13.46cm at the end of incubation. Collectively, the results suggest that the M4 formulation provided a favorable balance between nutrient availability and substrate physical properties, making it suitable for stable mycelial growth and practical spawn production.

Table 2. Mycelial growth rate of level III spawn

Time interval (days)	Mycelial length (cm/day)				
	M1 (Control)	M2	M3	M4	M5
3 - 6	0.71	0.62	1.11	0.57	0.85
6 - 9	1.18	0.89	0.63	0.61	0.77
9 - 12	0.43	0.46	0.27	0.56	0.34
12 - 15	0.47	0.11	0.35	0.42	0.34
15 - 18	0.29	0.23	0.32	0.94	0.82
18 - 21	0.00	0.83	1.23	0.07	0.57

The results obtained after 21 days of incubation demonstrated that nutrient substrate composition markedly affected the mycelial growth rate and development of level III spawn of *P. citrinopileatus* (Table 2). Differences in mycelial length among treatments at each observation time reflected the varying capacities of the substrates to provide carbon and nitrogen sources, as well as suitable physical conditions for mycelial colonization. Among the tested formulations, M1 (99% rice grain and 1% CaCO₃), which used rice grain as the sole primary substrate, exhibited the most rapid mycelial colonization throughout the cultivation period. This formulation represents a conventional substrate commonly used in spawn production. The mycelial growth rate in M1 was particularly pronounced between days 6 and 9 of incubation. Moreover, relatively low standard deviation values were observed at most sampling times, indicating high uniformity among cultivation bags and stable mycelial development. By day 18, the mycelium reached a length of 13.52cm and completely colonized the substrate earlier than the remaining treatments. The enhanced colonization efficiency of M1 may be attributed to the nutritional characteristics of rice grain, which is rich in easily metabolizable carbohydrates, proteins, and essential minerals that facilitate nutrient absorption and promote vigorous mycelial growth. In addition, the granular structure of rice grain provides favorable aeration, thereby ensuring adequate oxygen exchange required for aerobic mycelial growth. Previous studies have similarly reported that *Pleurotus citrinopileatus* exhibits enhanced mycelial growth on nutrient-rich substrates, producing dense and uniform mycelial networks [8].

The supplementation of corn bran and wheat bran in M2 increased the availability of proteins, B-complex vitamins, and essential minerals required for fungal growth. However, the mycelial colonization rate in this

formulation remained lower than that observed in M1 throughout most of the incubation period. This reduction may be attributed to the fine particle size of bran materials, which decreased substrate porosity and restricted oxygen diffusion within the substrate matrix. Previous studies have reported that excessively nutrient-rich substrates with high substrate density can reduce mycelial extension due to limitations in aerobic respiration [14]. However, by the end of the incubation period (day 21 days), mycelial growth in M2 remained relatively favorable, with the mycelium reaching a length of 13.10cm, indicating that the nutrient composition of this formulation was sufficient to support fungal growth.

In M3, replacing 50% of the rice grain with corn cob significantly reduced the mycelial growth rate during the early stage of cultivation. Corn cob possesses a coarse structure and contains higher levels of lignin and fibrous components that are more difficult to degrade than the starch-rich rice grain substrate. Consequently, the mycelium required additional time to adapt and synthesize extracellular enzymes necessary for utilizing this lignocellulosic material. The results showed that mycelia grown on M3 developed slowly, producing thinner and less uniformly distributed hyphae during most of the incubation period. Furthermore, the heterogeneous structure of corn cob reduced moisture retention stability and aeration capacity, thereby increasing the risk of mold contamination. Despite these limitations, the mycelium in M3 still reached a length of 13.42cm after 21 days of cultivation.

The M4 formulation, consisting of 40.5% rice grain, 40.5% sawdust, 3% corn bran, 15% wheat bran, and 1% CaCO₃, exhibited particularly promising performance. Although the initial mycelial colonization rate was lower than that observed in M1, mycelial development remained stable and uniform throughout the incubation period, reaching 13.52cm after 21 days, which was comparable to the control formulation. The incorporation of sawdust likely improved substrate porosity, enhanced moisture retention, and facilitated adequate aeration for mycelial growth. In addition, the combination of readily metabolizable carbon sources derived from rice grain and lignocellulosic materials derived from sawdust may have contributed to a more balanced nutritional environment for fungal development. Previous studies have similarly demonstrated that substrates with favorable aeration support vigorous mycelial growth and reduce contamination incidence in *P. citrinopileatus* cultivation [8].

The M5 formulation, composed of rice grain, corn cob, and sawdust, provided relatively favorable porosity and moisture retention capacity. However, the high proportion of corn cob negatively affected nutrient availability for mycelial growth. Consequently, mycelial extension remained lower than that observed in M1 and M4 throughout most stages of incubation. Moreover, greater variability in mycelial growth recorded at several observation points suggested greater variability in mycelial development among spawn bags. Experimental observations also revealed a relatively high contamination rate accompanied by uneven mycelial colonization. By the end of the incubation period (21 days), the mycelium attained a radial extension of 13.46cm, indicating near-complete substrate colonization. Furthermore, the incorporation of multiple substrate components at similar proportions may increase the risk of heterogeneous mixing and insufficient sterilization, potentially generating localized zones with elevated moisture and temperature that favor the proliferation of contaminating microorganisms.

The obtained results indicated that, although M1 exhibited the highest mycelial colonization rate, the M4 formulation, consisting of 40.5% rice grain, 40.5% sawdust, 3% corn bran, 15% wheat bran, and 1% CaCO₃, was considered more suitable for practical spawn production. This formulation maintained mycelial quality comparable to the control while enabling the utilization of sawdust, an abundant and inexpensive agricultural by-product. Partial substitution of rice grain with sawdust therefore represents a cost-effective strategy without compromising spawn quality. These findings highlight the potential applicability of the M4 formulation for large-scale commercial spawn production within the framework of sustainable agriculture and circular bioeconomy development.

4. CONCLUSIONS

This study demonstrates that substrate composition and mixing ratio play a decisive role in determining the growth performance and morphological characteristics of level III spawn of *P. citrinopileatus*. Among the tested formulations, M4 (40.5% rice grain, 40.5% sawdust, 3% maize bran, 15% wheat bran, and 1% CaCO₃) consistently showed superior performance under the experimental conditions (24 - 28°C, 21 days). M4 supported rapid and stable colonization, producing dense, uniformly distributed mycelium with strong substrate adhesion, while maintaining relatively low contamination levels.

The mean mycelial length reached 13.52 ± 0.12 cm, indicating effective growth under this formulation. The improved performance of M4 is likely associated with the combined effects of rice grain and sawdust, which contribute to a balanced substrate structure with enhanced porosity, aeration, moisture retention, and nutrient availability, thereby facilitating efficient mycelial development. Collectively, M4 represents the most suitable formulation for level III spawn production, offering a favorable balance between growth efficiency, contamination control, and economic feasibility. These findings provide a practical basis for optimizing spawn production systems and support the scalable and sustainable cultivation of *P. citrinopileatus*.

ACKNOWLEDGEMENTS

This research was supported by a provincial science and technology project in Bac Ninh Province (code: KCBN-(01).24).

REFERENCES

- [1]. F. Musieba, S. Okoth, R. Mibey, S. Wanjiku, K. Moraa, "Proximate composition, amino acids and vitamins profile of *Pleurotus citrinopileatus* singer: an indigenous mushroom in Kenya," *American Journal of Food Technology*, 8(3), 200-206, 2013. doi: 10.3923/ajft.2013.200.206.
- [2]. C. M. Yin, X. Fan, C. Liu, Z. Fan, D. F. Shi, F. Yao, W. Cheng, H. Gao, "The antioxidant properties, tyrosinase and α -glucosidase inhibitory activities of phenolic compounds in different extracts from the golden oyster mushroom *Pleurotus citrinopileatus* (Agaricomycetes)," *International Journal of Medicinal Mushrooms*, 21(9), 865-874, 2019. doi: 10.1615/IntJMedMushrooms.2019031857.
- [3]. T. Nagai, R. Inoue, H. Inoue, N. Suzuki, "Preparation and antioxidant properties of water extract of propolis," *Food chemistry*, 80(1), 29-33, 2003. doi: 10.1016/S0308-8146(02)00231-5.
- [4]. J. Attarat, T. Phermthai, "Bioactive compounds in three edible *Lentinus* mushrooms," *Walailak Journal of Science and Technology (WJST)*, 12(6), 491-504, 2015. doi: 10.2004/wjst.v12i2.842.
- [5]. J. H. Kim, S. J. Kim, H. R. Park, J. I. Choi, Y. C. Ju, K. C. Nam, S. J. Kim, S. C. Lee, "The different antioxidant and anticancer activities depending on the color of oyster mushrooms," *Journal of Medicinal Plants Research*, 3(12), 1016-1020, 2009.
- [6]. F. Y. Fan, L. X. Sang, M. Jiang, "Catechins and their therapeutic benefits to inflammatory bowel disease," *Molecules*, 22(3), 484, 2017. doi: 10.3390/molecules22030484.
- [7]. Deepika, P. K. Maurya, "Health benefits of quercetin in age-related diseases," *Molecules*, 27(8), 2498, 2022. doi: 10.3390/molecules27082498.
- [8]. Nguyen Hoang Thanh, Nguyen Tuong Vi, Tran Nhan Dung, Do Tan Khang, "Study appropriate media and substrates for production of Golden Mushroom (*Pleurotus citrinopileatus* Singer)," *Can Tho University Journal of Science*, 55(2), 95-102, 2019. doi:10.22144/ctu.jsi.2019.049
- [9]. Nguyen Thi Huyen Trang, Le Van Ve, Phan Thi Huyen Trang, Nguyen Thi Luyen, Ngo Xuan Nghien, Nguyen Thi Bich Thuy, "Mycelial Growth and Fruiting Body Development of Golden Oyster Mushroom (*Pleurotus citrinopileatus*) on Different Culture Substrates," *Vietnam J. Agri. Sci.*, 20, 5: 642-651, 2022.
- [10]. Nguyen Thi Nguyen, Huynh Thi Kim Cuc, Tran Thuc, Tran Thi Le Hang, Vu Thi Mui, *Mushroom Spawn Production Module Manual*. Ministry of Agriculture and Rural Development Publishing House, Hanoi, Vietnam, 2010.
- [11]. Ministry of Agriculture and Rural Development, *Overview of Mushroom Spawn Production and Mushroom Cultivation*. Ministry of Agriculture and Rural Development Publishing House, Hanoi, Vietnam, 2009.
- [12]. Le Xuan Tham, *Oyster Mushroom*. Science and Technology Publishing House, Hanoi, 2010.
- [13]. Nguyen Thi Bich Hang, Ngo Thi Hong Van, "Breeding and raising *Pleurotus citrinopileatus* in Da Nang City," *UED Journal of Sciences, Humanities & Education*, 5(4B), 9-15, 2015.
- [14]. Stamets, P, *Growing Gourmet and Medicinal Mushrooms, 3rd Edition*. Ten Speed Press, Berkeley, 2000.