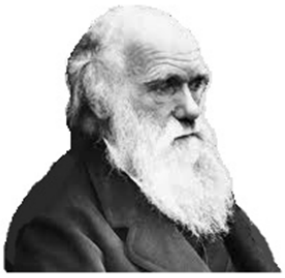
Available online at https://www.worldnewsnaturalsciences.com/



World News of Natural Sciences

An International Scientific Journal

WNOFNS 66 (2026) 193-200 EISSN 2543-5426

Standardization, quality control, and functional characterization of Tamogi mushroom [*Pleurotus citrinopileatus* Singer (1943)] filter tea: toward a product internal standard for functional food applications. Part II

Nguyen Vu Thu Phuong[1,*], Vu Thi Van Phuong[1], Vu Hong Nhung[1], Nguyen Thi Huong[2]

[1] VietRAP Center for Scientific Research and Development, VietRap Trading Investment JSC, Hanoi, Vietnam

[2] High Technology Innovation Center, Vietnam Academy of Science and Technology, Hanoi, Vietnam

*E-mail address: phuongnvt.vietrap@gmail.com

ABSTRACT

The increasing demand for functional beverages derived from medicinal mushrooms necessitates robust standardization frameworks to ensure product quality, safety, and efficacy. This study presents the development and validation of a Product Internal Standard for Tamogi filter tea formulated from *Pleurotus citrinopileatus* and synergistic medicinal ingredients, including *Cordyceps militaris*, *Trametes versicolor*, *Ganoderma* spp. and *Glycyrrhiza glabra*. A multi-dimensional quality control approach integrating sensory, physicochemical, microbiological, and bioactive compound analyses was applied. Key parameters, including moisture content, ash values, and β-glucan concentration, were quantified. Analytical techniques, including UV-Vis spectrophotometry and standardized microbiological assays, were applied to evaluate product quality and safety according to national regulatory frameworks. Heavy metal contamination (Pb, Cd, and As) was determined via ICP-MS. Results demonstrated that the developed product meets stringent quality criteria (moisture <8%, β-glucan >20 mg/mL, absence of pathogenic microorganisms, and heavy metals within permissible limits). Notably, the high β-glucan content supports potential immunomodulatory functionality. The proposed TCCS provides a scalable and scientifically grounded model for the standardization and

(Received 09 April 2026; Accepted 07 May 2026; Date of Publication 08 May 2026)

commercialization of mushroom-based functional teas, contributing to value chain development and sustainable utilization of medicinal fungi.

Keywords: Functional tea, *Pleurotus citrinopileatus*, β-glucan, standardization, quality control, medicinal mushrooms

1. INTRODUCTION

Medicinal mushrooms have gained increasing scientific and commercial interest due to their bioactive compounds, particularly β-glucans, polysaccharides, and phenolics, which exhibit immunomodulatory, antioxidant, and anti-inflammatory properties (Rathore, H. et al. 2017; Chang, S. T. et al. 2017). Among them, *Pleurotus citrinopileatus* (Tamogi mushroom), known for its β-glucan, is emerging as a promising functional ingredient due to its high nutritional value and bioactive potential (Siwulski, M. et al. 2017; Rodrigues, D.M.F.C. et al. 2015; Lin, S.Y. et al. 2016; Lee, Y.L. et al. 2007; Yıldız, S. et al. 2017; Hu, S. et al. 2006; Hu, S. et al. 2005). Tamogi mushrooms were cultivated under GACP-WHO conditions to ensure traceability and phytochemical consistency. Additional medicinal components were selected based on synergistic bioactivity, including *Cordyceps militaris* for its immunomodulation, *Trametes versicolor* for its polysaccharides (PSK/PSP), *Ganoderma* spp. for its triterpenoids and *Glycyrrhiza glabra* for its natural sweetener and anti-inflammatory (Heleno, S. A. et al. 2015). The formulation was optimized to balance sensory acceptability and functional efficacy.

Despite the growing popularity of mushroom-derived beverages, a critical bottleneck remains: the lack of standardized quality control systems that ensure consistency across production batches. In emerging markets such as Vietnam, the establishment of Product Internal Standards is essential to bridge the gap between traditional processing and modern regulatory requirements. Furthermore, global trends in functional foods emphasize not only safety but also quantifiable bioactivity (Dwyer JT., 2022; Nicolae Al. et al, 2001). Therefore, establishing a Product Internal Standard with regulatory compliance is essential to ensure consistent quality, safety, and efficacy, and represents a key step toward international market acceptance. This study aims to develop a comprehensive Product Internal Standard for Tamogi filter tea, evaluate physicochemical, microbiological, and bioactive properties, and provide a scalable model for functional tea standardization in locally-produced products in Vietnam.

2. MATERIALS AND METHODS

2. 1. Materials and equipment

Fresh Tamogi mushrooms were obtained from VietRap's GACP-WHO-compliant cultivation model in Luong Son, Vietnam. Additional dried ingredients, including *Cordyceps militaris*, *Trametes versicolor*, *Agaricus blazei*, and *Glycyrrhiza glabra* were supplied by VietRap. The following steps were established to produce the Tamogi mushroom's filter tea (Jha DK. et al. 2020). Previously sliced and dried Tamogi mushroom pieces, *Cordyceps*, *T. versicolor*, *A. blazei* mushroom powder, jujube fruit powder and *G. glabra* were coarse ground below 80 mesh. All the powders were mixed. Finally, they were packaged into tea bags at 2.5g per bag.



Figure 1. Morphology of the fruiting body of Tamogi golden oyster mushroom.

Equipment used were a grinder (Model Sqm-2L, Changsha Samy, China), a tea packing machine (Model STB-15, Synda Pack, China), a UV-Visible spectrophotometer (Model UV-1800, Shimadzu, Japan), an analytical balance (Model ME204, Mettler Toledo, Switzerland), a hotplate magnetic stirrer (Model C-MAG HS 7, IKA) and a drying oven (Model UN55, Memmert, Germany).

2. 2. Analytical methods

Sampling

Tea bag samples (25) were randomly collected according to TCVN 5609:2007 (Directorate for Standards, Metrology and Quality - Ministry of Science and Technology of Vietnam, 2007). Samples were labeled and recorded with full traceability. Each parameter was analyzed in triplicate.

2. 2. 1. Organoleptic evaluation

Sensory evaluation was conducted for color, aroma, and taste. Each tea bag (2.0 g) was infused in 200 mL of distilled water at 95 ±2 °C for 3–7 minutes. Sensory criteria to be assessed were clear to slightly turbid infusion, yellow to brown color, characteristic mushroom aroma, mild umami and slightly sweet taste, and no bitterness.

2. 2. 2. Moisture content

Moisture content was determined according to TCVN 5613:2007 in triplicate measurements with deviation ≤ 0.3% (Directorate for Standards, Metrology and Quality - Ministry of Science and Technology of Vietnam, 2007).

2. 2. 3. Ash contents

Total ash and acid-insoluble ash were determined per TCVN 5612:2007 in triplicate analysis (Directorate for Standards, Metrology and Quality - Ministry of Science and Technology of Vietnam, 2007).

2. 2. 4. β-glucan content

β-glucan content was determined using UV-Vis/HPLC following TCVN 12629:2019 (Directorate for Standards, Metrology and Quality - Ministry of Science and Technology of Vietnam, 2019).

2. 2. 5. Contents of heavy metals (Pb, Cd, As)

Heavy metals (Pb, Cd, As) were analyzed by ICP-MS according to QCVN 8-2:2011/BYT (Ministry of Health of Vietnam, 2011).

2. 2. 6. Microbiological Analysis

Total aerobic count, yeasts and molds, coliforms and *Salmonella* were assessed according to QCVN 8-3:2012/BYT (Ministry of Health of Vietnam, 2012).

2. 2. 7. Data Processing

Results represent batch quality. Non-compliant batches are rejected after re-testing.

3. RESULTS AND DISCUSSION

3. 1. Sensory characteristics

The dry tea material exhibited a fine, free-flowing powder without agglomeration, indicating appropriate drying and milling conditions. This physical uniformity is critical for ensuring consistent extraction during infusion and reflects effective control of moisture content, which minimizes clumping and microbial risk.

Upon brewing, the infusion presented a clear to slightly turbid appearance with a color ranging from yellow to light brown. This coloration is characteristic of mushroom-based beverages and is likely associated with water-soluble polysaccharides and phenolic compounds formed during drying. The absence of excessive turbidity or sediment suggests good filtration performance of the tea bag matrix and appropriate particle size distribution. The infusion exhibited a distinct mushroom aroma, described as characteristic, mild, and pleasant by the sensory panel.

This aroma is primarily attributed to volatile compounds such as alcohols, aldehydes, and ketones commonly found in edible mushrooms.

The presence of complementary herbal ingredients (e.g., *Ganoderma* spp., *Cordyceps militaris*, and *Trametes versicolor*) may contribute subtle earthy and woody notes, enhancing the overall aromatic complexity (Yang, J.Y, et al. 2025). Importantly, no off-odors (e.g., musty, sour, or burnt notes) were detected, indicating proper raw material quality and controlled processing conditions.

The taste profile was characterized as mildly sweet with a smooth, umami-like mouthfeel and no detectable bitterness or astringency. The slight sweetness is likely derived from *Glycyrrhiza glabra* (licorice), which contains glycyrrhizin, a natural sweetener significantly sweeter than sucrose (Wahab S., et al. 2021). Meanwhile, the umami sensation can be associated with free amino acids and nucleotides present in mushroom extracts.

The absence of bitterness, commonly reported in some medicinal mushroom preparations, suggests that the formulation successfully balances bioactive components with palatability, which is a critical factor for consumer acceptance and repeat consumption. Overall, the combination of a visually appealing infusion color, characteristic aroma, and pleasant taste indicates that the Tamogi filter tea meets desirable sensory standards for functional beverages. From a product development perspective, these attributes suggest that the formulation achieves a suitable balance between functionality (bioactive compounds such as β-glucan) and sensory quality. In comparison with other mushroom-based teas reported in the literature, which often exhibit strong earthy flavors and consumer resistance due to bitterness, the present formulation demonstrates improved palatability.

This enhancement can be attributed to the synergistic formulation strategy, particularly the inclusion of licorice as a natural flavor modulator. Thus, the favorable sensory profile supports the commercial potential of Tamogi filter tea as a functional beverage and validates its inclusion within the proposed Product Internal Standard. Future studies should incorporate quantitative sensory analysis using hedonic scoring and consumer preference testing to further substantiate market acceptance.

3. 2. Physicochemical quality

The Tamogi filter tea exhibited favorable physicochemical characteristics that support both product stability and functional value. The moisture content was determined to be 4.45%, remaining below the specified limit of 5%, which is essential for inhibiting microbial growth and prolonging shelf life. Ash analysis revealed low levels of inorganic residues, with total ash at 0.15% (limit ≤8%) and acid-insoluble ash at 0.27% (limit ≤1%). These values indicate minimal contamination from extraneous materials such as soil or silicates, reflecting the high purity and quality of the raw ingredients. The β-glucan content reached 22,1g/100g, substantially exceeding the minimum requirement. This elevated level highlights the strong functional potential of the product, as β-glucans are widely recognized for their immunomodulatory properties.

Mechanistically, β-glucans are known to activate macrophages, regulate cytokine production, and enhance innate immune responses (Muthuraman K.R., et al. 2026). In addition, the presence of co-formulated ingredients such as *Ganoderma* spp., *Cordyceps militaris*, and *Trametes versicolor* may contribute complementary bioactive compounds, including polyphenols and triterpenoids, which can synergistically improve antioxidant capacity (Yang, J.Y, et al. 2025). Notably, the β-glucan concentration observed in this study is comparable to or exceeds levels reported in commercial mushroom-based functional beverages, further supporting the product's competitive functional positioning.

3. 3. Microbiological safety

The Tamogi filter tea demonstrated excellent microbiological quality. The total aerobic plate count was 1,1 × 10^2 CFU/g, well below the acceptable limit of 10^3 CFU/g. Yeasts and molds were detected at 1,1 × 10^2 CFU/g (limit <10^3 CFU/g) and pathogenic microorganisms, including *Escherichia coli*, coliforms and *Salmonella*, were absent. These results confirm full compliance with applicable food safety standards and indicate a high level of hygienic control throughout processing. The absence of indicator organisms such as coliforms, as well as foodborne pathogens like *Salmonella*, reflects the effectiveness of good manufacturing practices (GMP) and proper handling of raw materials and finished products.

3. 4. Heavy metal assessment

The concentrations of heavy metals in the Tamogi filter tea were found to be well within permissible limits. Lead (Pb) was measured at 0.029 mg/kg (limit ≤5 mg/kg), cadmi (Cd) was quantified at 0.350 mg/kg (limit ≤1 mg/kg), while arsenic (As) was detected at 0.091 mg/kg (limit ≤2 mg/kg). These values are substantially lower than the regulatory thresholds, indicating minimal environmental contamination and confirming the safety and reliability of the raw material sourcing.

3. 5. Product Internal Standard requirements

Based on the overall quality evaluation, a Product Internal Standard (TCCS 2025 VietRAP following Decision No. 38/QĐ-VietRAP dated 2025 Nov. 27th) was established to ensure consistent product quality and safety. The sensory specifications describe a dry, fine powder that yields a yellow to brown infusion with a characteristic mushroom aroma and a mildly sweet taste. The physicochemical criteria include moisture content ≤5.0%, total ash ≤8.0%, acid-insoluble ash ≤1.0%, and β-glucan content ≥20 mg/mL. Heavy metal limits are defined as Pb ≤5 mg/kg, Cd ≤ 1 mg/kg, and As ≤2 mg/kg. These values are equivalent to the applied regulatory thresholds, indicating minimal environmental contamination and confirming the safety and reliability of the raw material sourcing. Microbiological requirements specify total aerobic counts ≤10^3 CFU/mL, yeasts and molds ≤10^3 CFU/mL, and the absence of *E. coli*, coliforms, and *Salmonella*. This TCCS framework integrates regulatory compliance (QCVN standards), sensory quality attributes and key functional markers, particularly β-glucan, thereby establishing a comprehensive model that bridges conventional quality standards and functional food validation.

4. CONCLUSION

This study successfully developed a Product Internal Standard for Tamogi filter tea, integrating sensory, physicochemical, microbiological, and functional quality parameters. The product demonstrates high β-glucan content, excellent microbiological safety, and compliance with heavy metal regulations.The proposed framework provides a scientific basis and scalable model for functional food standardization, contributing to the valorization of medicinal mushrooms and supporting commercialization of Tamogi tea as a functional beverage and sustainable agro-based value chains.

ACKNOWLEDGMENT

The authors acknowledge financial support from Project No. 08/HĐ-KHCNNTM-2025 under the National New Rural Development Program in collaboration with VietRap Trading Investment JSC.

References

[1] Rathore, H., Prasad, S., & Sharma, S. (2017). Mushroom nutraceuticals for improved nutrition and better human health: A review. *Pharmacognosy Reviews*, 11(22), 35-46

[2] Chang, S. T., & Wasser, S. P. (2017). The role of culinary-medicinal mushrooms on human welfare. *International Journal of Medicinal Mushrooms*, 19(4), 293-318

[3] Siwulski, M.; Mleczek, M.; Rzymski, P.; Budka, A.; Jasi ´nska, A.; Niedzielski, P.; Kalaˇc, P.; Gasecka, M.; Budzy ´nska, S.; Mikołajczak, P. Screening the multi-element content of Pleurotus mushroom species using inductively coupled plasma optical emission spectrometer (ICP-OES). *Food Anal. Methods* 2017, 10, 487-496

[4] Rodrigues, D.M.F.C.; Freitas, A.C.; Rocha-Santos, T.A.P.; Vasconcelos, M.W.; Roriz, M.; Rodríguez-Alcalá, L.M.; Gomes, A.M.P.; Duarte, A.C. Chemical composition and nutritive value of Pleurotus citrinopileatus var cornucopiae, P. eryngii, P. salmoneo stramineus, Pholiota nameko and Hericium erinaceus. *J. Food Sci. Technol.* 2015, 52, 6927-6939

[5] Lin, S.Y.; Chien, S.C.; Wang, S.Y.; Mau, J.L. Non-volatile taste components and antioxidant properties of fruit body and mycelium with high ergothioneine content from the culinary-medicinal golden oyster mushroom Pleurotus citrinopileatus (Agaricomycetes). *Int. J. Med. Mushrooms* 2016, 18, 689-698

[6] Lee, Y.L.; Huang, G.W.; Liang, Z.C.; Mau, J.L. Antioxidant properties of three extract from Pleurotus citrinopileatus. *LWT Food Sci. Technol.* 2007, 40, 823-833

[7] Yıldız, S.; Yılmaz, A.; Can, Z.; Kılıç, C.; Yıldız, Ü.C. Total phenolic, flavonoid, tannin contents and antioxidant properties of Pleurotus ostreatus and Pleurotus citrinopileatus cultivated on various sawdust. *GIDA J. Food* 2017, 42, 315-323

[8] Hu, S.; Liang, Z.; Chia, Y.; Lien, J.; Chen, K.; Lee, M.; Wang, J. Antihyperlipidemic and Antioxidant Effects of Extracts from Pleurotus citrinopileatus. *J. Agric. Food Chem.* 2006, 54, 2103-2110

[9] Hu, S.; Wang, J.; Lien, J.; Liaw, E.; Lee, M. Antihyperglycemic effect of polysaccharide from fermented broth of Pleurotus citrinopileatus. *Appl. Microbiol. Biotechnol.* 2005, 70, 107-113

[10] Heleno, S. A., Barros, L., Martins, A., Queiroz, M. J. R. P., Santos-Buelga, C., & Ferreira, I. C. F. R. (2015). Nutritional value, bioactive compounds and antioxidant properties of three edible mushrooms from Poland. *Food Chemistry*, 173, 964-969

[11] Dwyer JT. Have safety and efficacy assessments of bioactives come of age? *Mol Aspects Med.* 2023; 89: 101103. doi: 10.1016/j.mam.2022.101103

[12] Nicolae Al. Pop, Ciprian-Marcel Pop, Dan-Cristian Dabija. Standardization – a solution to product counterfeiting in international markets. *Journal of Business Research,* 52 (1), pp.1-14, 2001

[13] Yang JY, Tao L, Lou D, Patabendige NM, Ediriweera AN, Liu S, Lu W, Tarafder E, Rapior S, Hapuarachchi KK. Innovative applications of medicinal mushrooms in functional foods and nutraceuticals: a focus on health-boosting beverages. *Front Cell Infect Microbiol.* 2025; 15: 1605301. doi: 10.3389/fcimb.2025.1605301

[14] Wahab S, Annadurai S, Abullais SS, Das G, Ahmad W, Ahmad MF, Kandasamy G, Vasudevan R, Ali MS, Amir M. Glycyrrhiza glabra (Licorice): A Comprehensive Review on Its Phytochemistry, Biological Activities, Clinical Evidence and Toxicology. *Plants (Basel),* 2021; 10(12): 2751. doi: 10.3390/plants10122751

[15] Muthuraman KR, Kato T, Kusano K, Moriya Y, Park EY. β-Glucans and their roles in immune and metabolic regulation: A review. *Int J Biol Macromol.* 2026; 338(Pt 2): 149746. doi: 10.1016/j.ijbiomac.2025.149746