

Development and Market Potential of Oyster Mushroom Powder

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ABSTRACT

Oyster mushroom powder offers significant health benefits, including being a rich source of dietary fiber, antioxidants, and essential nutrients, making it an ideal ingredient for functional foods aimed at promoting overall wellness. Despite its potential, limited studies have thoroughly explored optimal production methods, physico-chemical properties, and market readiness of mushroom powder, leaving a gap in the industry's understanding of how to best produce and commercialize this product. Hence, this study aimed to address this gap by evaluating the production, quality, and market potential of oyster mushroom powder through five key objectives. A descriptive research design was employed, utilizing both quantitative and qualitative methods to gather comprehensive data. First, it developed a suitable drying method, determining that drying at 60-80°C for one hour produced optimal powder quality in terms of color and fineness. Second, the physico-chemical properties of the powder were assessed, revealing a moisture content of 8.5%, pH level of 6.2, and an acceptable particle size distribution, meeting industry standards for powdered products. Third, the organoleptic properties were evaluated using a 5-point scale (with 5 being highly acceptable) through consumer surveys conducted with 100 respondents, showing high acceptability across attributes such as appearance (mean score of 4.51), aroma (4.48), taste (4.44), and packaging (4.50). These results highlight the product's overall positive reception and potential for consumer satisfaction. Fourth, microbiological tests conducted in accordance with FDA guidelines demonstrated that the powder was free from harmful contaminants such as *Clostridium perfringens*, *Salmonella*, and *E. coli*, while the levels of yeast, mold, and coliforms were within acceptable limits, ensuring product safety. Finally, the market potential analysis revealed that consumers prefer smaller packaging sizes, particularly 100g with a pricing preference of PHP 205.00 for pouch packaging, and 60g with a preference of PHP 150.00 for bottle jars. The results highlight a strong market inclination towards convenient, well-priced, and high-quality mushroom powder. Recommendations include focusing on consumer-preferred packaging sizes and pricing strategies, adhering to stringent safety standards, and enhancing packaging features to meet market demands. This comprehensive approach positions the oyster mushroom powder favorably in the market, catering to consumer needs and ensuring product quality and safety.

Keywords: Oyster Mushroom Powder, Drying Method, Physico-Chemical Properties, Organoleptic Evaluation, Market Potential

INTRODUCTION

Oyster mushrooms (*Pleurotus ostreatus*) have gained considerable popularity due to their culinary versatility and distinctive flavor. Often found growing on trees, these mushrooms are celebrated in Asian cuisine for their delicate fragrance, reminiscent of anise, and their unique fan-shaped appearance. Beyond their culinary appeal, oyster mushrooms are increasingly recognized for their health benefits and medicinal properties. They are rich in essential nutrients, dietary fiber, minerals, and antioxidants, making them a valuable addition to a balanced diet. Research has highlighted their remarkable medicinal properties, including anti-inflammatory, antimicrobial, and immune-enhancing effects, which contribute to their growing demand in both food and health industries. Globally, mushroom production has seen significant growth over the past three decades, with total production reaching 42.8 million tons between 1990 and 2020. Oyster mushrooms have carved out an important position within this rapidly expanding industry, particularly in the Philippines. The country's mushroom industry has developed substantially, producing approximately 27,000 metric tons annually. This growth is driven by the economic practicality of mushroom cultivation in the Philippines, where low production costs, the availability

of inexpensive agricultural waste materials, and strong market demand have made mushroom farming an attractive venture.

However, mushrooms are highly perishable and susceptible to rapid deterioration due to their high-water content. This vulnerability can lead to discoloration, deformities, and a reduction in quality, making effective preservation methods essential. One such method is powdering mushrooms, which extends their shelf life while maintaining quality. Oyster mushroom powder, in particular, offers versatility in culinary applications, enhancing the flavors of a wide range of dishes, from soups and stews to baked goods and dry rubs for meat and vegetables. This versatility, combined with the growing number of health-conscious consumers, has led to increased demand for nutritious food products that cater to a more health-oriented lifestyle. Consumer health consciousness plays a significant role in their willingness to pay for health and wellness products. Studies have shown that a considerable percentage of consumers are interested in adopting healthier eating habits, which has further fueled the demand for products like oyster mushroom powder. Sensory evaluations of food items incorporating oyster mushroom powder, such as cakes and toffees, have received favorable ratings for taste and acceptability, highlighting the potential for this ingredient to be used in a variety of food products. Incorporating mushroom powder not only addresses nutritional deficiencies but also offers an innovative strategy for fortifying food with additional health benefits.

This study is grounded in the context of the growing market for functional food products, driven by increasing consumer awareness of the link between diet and health. Oyster mushroom powder has emerged as a potential functional ingredient due to its nutritional value and medicinal properties. Containing bioactive compounds associated with immune enhancement, anti-inflammatory effects, and antimicrobial properties, oyster mushroom powder offers significant potential in various industries, including food, supplements, and functional beverages. Several studies have demonstrated the successful incorporation of mushroom powder into various food products, such as noodles, baked goods, meat-based products, and soups. For instance, mushroom powder has been used in bakery products like biscuits, cakes, and bread to enhance their nutritional content. In addition, mushroom-fortified noodles have been developed with increased protein and fiber content, making them a healthier option for consumers. The addition of mushroom derivatives, such as mushroom powder or extracts, to meat-based products has also been shown to improve taste and consumer acceptance. Furthermore, mushroom powder has been used as an ingredient in soups, offering a convenient and health-promoting option in the food industry.

Despite the growing popularity of mushroom powders as functional food ingredients, there remains a notable gap in the comprehensive understanding of their processing, quality, and market potential. While research has explored various drying methods and their effects on the physical properties of mushroom powders, there is limited information on the optimal drying conditions for preserving both the quality and nutritional value of oyster mushroom powder specifically. Additionally, existing studies often overlook detailed assessments of the physico-chemical properties and organoleptic characteristics of these powders in relation to consumer preferences and market viability. This study addresses these gaps by evaluating different drying methods, assessing the physico-chemical and organoleptic properties, and identifying market potential through consumer insights. Understanding these factors is crucial for optimizing production processes, ensuring product quality, and meeting market demands effectively. Furthermore, a thorough analysis of the microbiological profile of oyster mushroom powder aligns with safety standards and helps ensure product reliability. The findings from this research will contribute valuable insights for producers aiming to enhance product quality, align with consumer preferences, and successfully enter or expand in the competitive market of mushroom-based products.

Objectives

1. Develop a suitable drying method for the production of mushroom powder
2. Evaluate the physico-chemical properties of the powder
3. Determine the organoleptic properties of the powder
4. Identify microbiological profile of oyster mushroom powder in relation to FDA guidelines, considering tests for contaminants such as *Clostridium perfringens*, Yeast and Mold Count, Coliforms, Aerobic Plate Count, and Salmonella
5. Identify market potential of oyster mushroom powder

REVIEW OF LITERATURE

The review of literature on oyster mushroom powder highlights its increasing popularity due to its nutritional benefits, culinary versatility, and potential health advantages. Oyster mushroom powder, particularly derived from *Pleurotus ostreatus*, is rich in proteins, vitamins B and D, minerals such as potassium and iron, and immune-boosting beta-glucans, making it a highly functional ingredient in various food products (Akib, 2023). The powder's versatility is evident in its use as a seasoning, thickener, and gluten-free flour alternative, as well as its role in enhancing both the taste and nutritional content of meals (Singh & Thakur, 2016).

Health benefits associated with mushroom powder are substantial. Kotasthane (2021) notes that oyster mushroom powder is low in cholesterol and high in essential nutrients, making it a healthy food option. Further, studies have revealed its potential anticancer properties and its use in reducing blood pressure, increasing resistance against diseases, and providing antioxidant and medicinal benefits due to its rich polyphenolic content (Krupodorova et al., 2016; Nayak et al., 2022). Additionally, the consumption of mushroom powder, particularly oyster mushrooms, has been linked to lowering the risk of various diseases, including heart disease, hypertension, diabetes, and certain types of cancer (Karmani et al., 2022; Siyame et al., 2021).

The review also discusses different processing methods for mushroom powder, emphasizing the importance of selecting a suitable drying method to retain its nutritional quality. Aishah and Rosli (2013) compared various drying methods and found that low-heat air blowing was effective in retaining fat and carbohydrate contents, while freeze-drying preserved the microstructure and nutritional components more effectively (Das et al., 2021). Other studies support the efficacy of freeze-drying, noting its advantages in water retention, foaming capacity, and overall sensory properties (Thi et al., 2020).

Farzana, B., Sarker, M. Z., & Begum, M. (2017) study entitled "Optimization of drying conditions for preservation and quality enhancement of mushroom powder," the authors explore the effects of different drying temperatures on mushroom quality. They found that drying at temperatures between 60-90°C effectively reduced the moisture content to within the optimal range of 5-10%. Maintaining moisture content within this range is crucial for extending the shelf life of mushroom powder while preserving its nutritional and sensory qualities. The study indicates that drying temperatures on the lower end of this spectrum (60-70°C) were preferable for retaining the powder's color and flavor, whereas higher temperatures (80-90°C) were associated with a greater risk of nutritional degradation and flavor loss due to increased Maillard reactions and caramelization.

Meanwhile, Kumar, A., & Ghosh, P. (2016) paper "Effect of drying temperature and time on the quality of mushroom powder" provides detailed insights into how drying temperatures influence mushroom powder quality. The researchers demonstrated that drying at 60-80°C for specified durations achieved a desirable moisture content of approximately 5-10%. They observed that this moisture range was optimal for ensuring the powder's stability and extending its shelf life. Excessively high temperatures, such as 90°C, can lead to rapid moisture evaporation, which, while initially effective, may cause undesirable changes in texture and nutrient content over time. The study underscores the balance between temperature and drying duration to achieve a high-quality mushroom powder with a stable shelf life.

Santos, J. T., & Nunes, L. M. (2021) in their research "Effect of drying temperatures on the quality and shelf-life of fruit and vegetable powders," the authors investigate the impact of varying drying temperatures on the quality of fruit and vegetable powders, including mushrooms. They highlight those drying temperatures between 60-90°C, when coupled with a moisture content of 5-10%, are effective for preserving both the quality and shelf life of powdered products. The study notes that this temperature range prevents excessive moisture retention while avoiding the adverse effects of higher temperatures, which can lead to thermal degradation of sensitive compounds.

Moisture content is another critical factor influencing the quality and shelf life of mushroom powder. Tran et al. (2023) found that maintaining a moisture content below 3% contributes to the stability and preservation of mushroom powder. Similarly, Rubina and Aboltins (2021) suggest that a moisture content range of 5% to 8% is ideal for ensuring product quality and extending shelf life. Lower moisture content helps inhibit microbial growth and enzyme activity, thus preserving the powder's nutritional properties (Sadli et al., 2021).

Market analysis reveals a growing demand for functional mushroom powder, with projections indicating significant market expansion in the coming years. According to Data Bridge Market Research (2023), the global market for functional mushroom powder is expected to grow at a compound annual growth rate (CAGR) of 5.8% from 2022 to 2029, driven by increasing consumer interest in health-conscious and nutrient-rich foods. This trend aligns with the study's objective to develop a product ready for commercialization.

Consumer acceptance of mushroom-enhanced products varies based on the concentration of mushroom powder used. Studies by Lavelli et al. (2018) and Salehi (2019) demonstrate that incorporating 4-10% mushroom powder into bakery products like bread, biscuits, and cakes enhances their vitamin, mineral, polyphenol, and protein content while maintaining favorable sensory properties. However, higher concentrations may result in decreased consumer acceptance due to changes in flavor and texture.

This literature review aligns with the study's objectives by providing comprehensive insights into the development of suitable drying methods, evaluation of the physico-chemical and organoleptic properties, and the importance of packaging and commercialization strategies for mushroom powder. These findings are crucial for developing a product that is not only nutritionally beneficial but also commercially viable.

MATERIALS AND METHODS

The research employed a descriptive design to systematically explore and analyze the production process and market potential of oyster mushroom powder. The study aimed to address five specific objectives: developing a suitable drying method, evaluating the physico-chemical properties of the powder, assessing its organoleptic characteristics, analyzing its microbiological safety, and identifying its market potential.

Sampling Technique and Population

A quota sampling technique was utilized to ensure a representative sample across key subgroups within the population of Siniloan, Laguna. This non-probability sampling method was chosen to guarantee that the sample reflected the diversity of perspectives among consumers, cooking enthusiasts, and retailers—three crucial market segments for oyster mushroom powder. A total of 100 respondents were selected, divided into three groups. This approach allowed the study to capture a broad range of opinions and preferences related to the product.

Data Collection Methods

Data collection for this study was meticulously aligned with the key objectives. To develop a suitable drying method for mushroom powder, a series of trials were conducted, varying drying temperatures and durations to identify optimal conditions. Meanwhile, evaluating the physico-chemical properties of the powder, involved precise measurements of moisture content using a moisture content meter and pH levels using an acidity meter, ensuring accurate assessment of the powder's stability and quality. Structured questionnaires were employed to collect quantitative data on respondents' preferences, attitudes, and behaviors regarding the mushroom powder, with specific attention to packaging, pricing, and perceived quality. This data was crucial for evaluating the organoleptic properties, such as appearance, texture, aroma, and taste. Additionally, in-depth interviews with a subset of respondents provided qualitative insights into their experiences and opinions, which were essential for identifying the market potential of the product. The microbiological profile of the powder was also assessed according to FDA guidelines, ensuring the product's safety and compliance. This comprehensive data collection approach ensured that each objective was thoroughly addressed, integrating both quantitative and qualitative methods.

DRYING METHODOLOGY

To address the first objective, a series of trials were conducted using a dehydrator machine to determine the most effective drying method. Different temperature settings and durations were tested, specifically ranging from 60-90°C and 60-80°C, with drying times varying from 1 to 6 hours. The drying methods were evaluated based on the resulting powder's physical appearance, color, fineness, moisture content, and pH level. The optimal method was identified through comparative analysis, where the combination of 60-80°C for 1 hour was determined to

yield the best results in terms of quality and processing efficiency.

Physico-Chemical Analysis

The second objective focused on analyzing the physico-chemical properties of the mushroom powder. Moisture content and pH levels using moisture and acidity meter were assessed to determine the optimal processing conditions. These parameters are critical for ensuring the quality and shelf life of the powder. The required moisture content was set according to industry standards, with an emphasis on achieving a balance that would maintain product quality while preventing microbial growth.

Organoleptic Evaluation

For the third objective, the organoleptic properties of the oyster mushroom powder, such as color, flavor, texture, and overall acceptability, were assessed through sensory evaluations. A panel consisting of both trained and untrained respondents from the selected sample groups participated in these evaluations. Sensory data were analyzed statistically to determine consumer preferences and identify the most acceptable formulation of the powder.

Microbiological Testing

The fourth objective involved a detailed microbiological analysis to ensure the safety and quality of the oyster mushroom powder in accordance with FDA guidelines. Samples were submitted to DOST CALABARZON and SGS Philippines Inc. for testing. The powder was tested for *Clostridium perfringens*, Yeast and Mold Count, Coliforms, Aerobic Plate Count, and Salmonella. The results were compared against FDA standards for dry mixes for soups and sauces, ensuring that the product met the necessary safety criteria for commercialization.

Market Analysis

Finally, the fifth objective focused on identifying the market potential of oyster mushroom powder. The study analyzed consumer preferences regarding packaging sizes, pricing, and qualitative requirements through the data collected from questionnaires and interviews. This analysis provided insights into the most preferred packaging sizes, pricing strategies, and potential market segments, highlighting critical factors that would influence the product's success in the market.

The comprehensive methodology employed in this study ensured a thorough investigation of all aspects related to the production, quality, safety, and marketability of oyster mushroom powder, providing a solid foundation for its potential commercialization.

RESULTS AND DISCUSSION

Suitable drying method for the production of mushroom powder

The primary objective of the study was to develop a suitable drying method for the production of oyster mushroom powder, which involved experimenting with different temperatures and durations to determine the optimal conditions for drying. To achieve this, a total of 11 trials were conducted and one control trial (Table 1). The control trial utilized a drying temperature range of 60-90°C for six hours, serving as a benchmark against which other conditions were compared. The control trial was selected based on established practices for drying mushrooms, as temperatures between 60-90°C are commonly used for preserving the quality and functionality of mushroom powders (Farzana et al., 2017; Liu et al., 2020). This temperature range was employed to examine the effects of prolonged drying time on the moisture content and overall quality of the mushroom powder. The control condition helped in understanding the standard outcome for drying at higher temperatures and longer durations, setting a reference point for comparison.

The first five experimental trials, conducted at a temperature range of 60-90°C, were designed to determine the impact of varying drying times on the quality of oyster mushroom powder. Starting with a 5-hour drying period,

each subsequent trial reduced the time incrementally to 4, 3, 2, and finally 1 hour. The aim was to assess how different durations affected moisture content and overall powder quality. Longer drying times, such as 5 hours, generally allowed for more moisture removal but risked over-processing, while shorter times, like 1 hour, tested the minimum duration needed to achieve effective moisture reduction. These trials helped identify the optimal balance between drying time and powder characteristics, providing insights into the efficiency and quality of the drying process within the specified temperature range.

The remaining six trials employed a temperature range of 60-80°C to refine the drying process for oyster mushroom powder. These trials systematically tested different drying times: 6, 5, 4, 3, 2, and 1 hour. The objective was to find the most effective combination of temperature and drying duration that would produce high-quality mushroom powder. Trials at this lower temperature range aimed to achieve a balance between efficient moisture removal and preservation of the powder's nutritional and sensory attributes. The results indicated that drying for 1 hour at 60-80°C yielded the optimal moisture content and quality, aligning with the study's goal of producing a powder with desirable characteristics, such as a fine texture and light beige color, which were critical for commercial viability. This temperature range was found to provide the best compromise between maintaining the powder's quality and ensuring stability, making it the preferred method for the production of high-quality oyster mushroom powder.

The findings from the remaining six trials, which tested drying durations of 6, 5, 4, 3, 2, and 1 hour at 60-80°C, reveal that drying for 1 hour at this temperature range yielded the optimal results. This aligns with previous research suggesting that a shorter drying time at moderate temperatures can effectively balance moisture removal while preserving the quality of mushroom powder. Liu, Chen, and Zhang (2020) highlighted that drying oyster mushrooms at temperatures between 60°C and 80°C achieves optimal moisture content, which is crucial for maintaining product quality and stability. Similarly, Wang, Wang, and Li (2018) found that drying at these temperatures produced mushroom powders with desirable physicochemical properties. Their studies support the observation that 1 hour at 60-80°C effectively meets the balance between moisture content and powder quality, making it an ideal condition for the production of high-quality oyster mushroom powder.

This result aligns with existing literature, which suggests that lower drying temperatures are often more effective in preserving the quality of mushroom products. For instance, Argyropoulos and Müller (2014) note that mushrooms are sensitive to heat and prolonged drying at high temperatures can lead to degradation of color, texture, and nutritional content. Specifically, excessive heat can cause browning reactions, often linked to the Maillard reaction, which not only affects the visual appeal of the mushroom powder but can also impact its flavor and nutritional profile (Krokida et al., 2003).

Moreover, the study's findings corroborate those of Parikh et al. (2018), who demonstrated that drying mushrooms at lower temperatures (around 60°C) better preserves their sensory attributes, including color and texture. Parikh et al. (2018) further argue that the degradation of certain bioactive compounds and pigments, such as polyphenols and flavonoids, is minimized at these lower temperatures, thus maintaining the nutritional and aesthetic quality of the dried product. The fineness of the powder, an essential factor for its reconstitution in various culinary applications, is also enhanced by careful control of drying temperature and time, as the study's results indicate.

The optimal drying conditions identified in this study—60°C to 80°C for 1 hour—are consistent with these findings and highlight the importance of fine-tuning drying parameters to balance efficiency and product quality. The success of this method likely stems from its ability to achieve a sufficient moisture reduction while minimizing the thermal stress on the mushroom tissues, thus preventing the degradation of color and ensuring the production of a fine, uniform powder.

In practical terms, this suggests that for small-scale producers or those in resource-limited settings, lower temperature drying methods are not only more energy-efficient but also more effective in producing high-quality mushroom powder. The implications for commercial production are significant, as the quality of the powder directly influences its marketability and consumer acceptance. As such, this study provides a valuable contribution to the existing body of knowledge on mushroom processing, offering a practical solution for producers seeking to maximize product quality while minimizing production costs.

Table 1: Drying Methods

Trial	Drying Temperature (°C)	Drying Time (hrs)	Appearance
Control	60-90	6	Dark beige, slightly coarse
Trial 1	60-90	5	Dark beige, slightly coarse
Trial 2	60-90	4	Light beige, slightly coarse
Trial 3	60-90	3	Light beige, fine texture
Trial 4	60-90	2	Light beige, fine texture
Trial 5	60-90	1	Light beige, fine texture
Trial 6	60-80	6	Dark beige, slightly coarse
Trial 7	60-80	5	Dark beige, slightly coarse
Trial 8	60-80	4	Dark beige, slightly coarse
Trial 9	60-80	3	Light beige, very fine
Trial 10	60-80	2	Light beige, fine texture
Trial 11	60-80	1	Light beige, fine texture

The physico-chemical properties of the powder

The physico-chemical analysis of oyster mushroom powder is a critical aspect of evaluating its overall quality and suitability for commercial use. This analysis involves examining key parameters such as moisture content, pH level, and appearance, all of which play a significant role in determining the product's stability, shelf life, and consumer appeal. Each of these factors must be carefully controlled and optimized during the production process to ensure the final product meets industry standards and consumer expectations. A total of 11 trials were conducted to assess the optimal drying method for oyster mushroom powder, with one control trial included for comparison (Table 2). The control trial involved drying at a temperature range of 60-90°C for six hours. The remaining 10 trials varied in drying temperature and time, ranging from 60-80°C and drying durations between one and five hours. Each trial was designed to evaluate the impact of these variables on key physico-chemical properties, including moisture content, pH level, and appearance.

Moisture content is one of the most crucial parameters in the physico-chemical analysis of mushroom powder. The drying method employed in this study, which involved using temperatures of 60-80°C for one hour, resulted in a moisture content of approximately 8.5%. This moisture level is critical because it falls within the optimal range of 5-10% recommended for mushroom powders to ensure stability and quality, as highlighted by Farzana et al. (2017) and Rubina & Aboltins (2021). Maintaining moisture content within this range is essential for several reasons. First, it helps to extend the shelf life of the product by reducing the likelihood of microbial growth, which thrives in environments with higher moisture levels. Second, it preserves the functional properties of the powder, ensuring that it remains free-flowing and easy to use in various culinary and food processing applications. Excessively high moisture content can lead to clumping and spoilage, while too low moisture can make the powder difficult to dissolve or incorporate into food products.

The pH level of the mushroom powder, which was measured at 6.2 in this study, is another vital parameter that influences the quality and safety of the product. The pH level of mushroom powder typically falls within the range of 5.5 to 6.5, as noted by Giri & Prasad (2007). This slightly acidic to neutral pH range is ideal for maintaining the stability and flavor of the powder while preventing the growth of harmful microorganisms. A pH level that is too low (too acidic) can lead to a sour taste and potential degradation of certain nutrients, while a pH level that is too high (too alkaline) can result in a bitter taste and decreased shelf life. The consistency in pH levels observed across different drying trials in this study indicates that the chosen drying method effectively controls the acidity of the product, ensuring that it remains within the desired range. This is crucial for ensuring

that the powder is safe for consumption and retains its nutritional and sensory qualities.

Appearance, including color, texture, and uniformity, is a critical aspect of consumer acceptance and marketability of mushroom powder. The study found that the mushroom powder produced using the 60-80°C drying method for one hour exhibited a light beige color, closely resembling the natural hue of fresh mushrooms. This is a desirable trait, as consumers typically associate lighter-colored powders with higher quality and freshness. The preservation of the natural color during the drying process suggests that the method effectively minimizes the occurrence of Maillard reactions and caramelization, which can lead to browning and a less appealing appearance. The color stability observed in this study is consistent with findings from Kumar et al. (2016), who noted that higher drying temperatures can cause darker colors due to increased Maillard reactions. This darker color can negatively affect consumer perception and acceptance, highlighting the importance of optimizing drying temperatures to achieve a visually appealing product.

The texture of the mushroom powder is another important aspect of its appearance and overall quality. The study reported that the powder produced at 60-80°C for one hour had a fine and uniform texture, which is ideal for its intended uses in food products. A fine texture ensures that the powder can be easily mixed, dissolved, or incorporated into various food applications without clumping or leaving behind a gritty residue. This characteristic is particularly important for products like mushroom powder, which are often used as flavoring agents, nutritional supplements, or functional ingredients in both home cooking and industrial food production. The study also observed that higher drying temperatures or extended drying times resulted in coarser textures, likely due to the formation of larger particles as moisture was removed more rapidly. This finding underscores the importance of controlling both temperature and time during the drying process to achieve the desired particle size distribution.

In addition to moisture content, pH level, and appearance, the overall sensory qualities of the mushroom powder, including taste and aroma, are also influenced by the drying process. Although this study primarily focused on physico-chemical properties, it is important to note that these factors are closely linked to the sensory attributes that consumers value. For instance, the preservation of a light beige color and fine texture suggests that the powder is likely to have retained its natural mushroom flavor and aroma, which are key drivers of consumer acceptance. The study's findings on the optimal drying conditions are supported by Liu, Chen, & Zhang (2020), who demonstrated that drying oyster mushrooms at temperatures between 60°C and 80°C resulted in a moisture content similar to the 8.5% found in this study, while also preserving the nutritional and sensory qualities of the product.

The physico-chemical properties of mushroom powder are also critical for ensuring the product's suitability for various commercial applications. For instance, the fine texture and stable pH observed in this study make the powder ideal for use in soups, sauces, and seasonings, where it can be easily dissolved or mixed without altering the taste or texture of the final product. The light color and fine texture also enhance the powder's appeal as a nutritional supplement, as these attributes suggest a high-quality product that is easy to incorporate into daily diets. Moreover, the stable pH and optimal moisture content help to ensure that the powder remains shelf-stable, reducing the risk of spoilage or degradation over time. This is particularly important for commercial products that may be stored for extended periods before reaching the consumer.

The findings of this study are further supported by the work of Narayan & Yadav (2019), who reported similar pH levels and moisture content in mushroom powders produced by different drying methods. Their research emphasized the importance of maintaining these physico-chemical properties to ensure the quality and safety of the final product. Additionally, the general drying conditions for mushroom products discussed by Wang, Wang, & Li (2018) align with the results of this study, confirming that drying temperatures between 60°C and 80°C are effective in producing mushroom powders with optimal moisture content and pH stability. These studies collectively underscore the significance of carefully controlling drying conditions to achieve a balance between moisture removal, pH stability, and visual appeal, all of which contribute to the overall quality of the mushroom powder.

By optimizing these physico-chemical properties, the mushroom powder produced in this study meets industry standards and consumer expectations, making it a viable product for the food and nutraceutical markets. The

results also underscore the importance of careful temperature and time control during the drying process to ensure that the final product maintains its quality and functionality, thereby supporting its commercial potential and consumer appeal.

Table 2: The physico-chemical properties of the powder

Trial	Drying Temperature (°C)	Drying Time (hrs)	Moisture Content (%)	pH Level	Appearance
Control	60-90	6	5.5	6.2	Dark beige, slightly coarse
Trial 1	60-90	5	6.5	6.3	Dark beige, slightly coarse
Trial 2	60-90	4	6.5	6.4	Light beige, slightly coarse
Trial 3	60-90	3	7.0	6.5	Light beige, fine texture
Trial 4	60-90	2	7.5	6.6	Light beige, fine texture
Trial 5	60-90	1	8.0	6.7	Light beige, fine texture
Trial 6	60-80	6	5.8	6.2	Dark beige, slightly coarse
Trial 7	60-80	5	6.7	6.3	Dark beige, slightly coarse
Trial 8	60-80	4	6.7	6.2	Dark beige, slightly coarse
Trial 9	60-80	3	7.3	6.3	Light beige, very fine
Trial 10	60-80	2	8.2	6.4	Light beige, fine texture
Trial 11	60-80	1	8.5	6.2	Light beige, fine texture

The organoleptic properties of the powder

The evaluation of the organoleptic properties of oyster mushroom powder reveals a favorable consumer reception across several attributes (Table 3). A consumer survey was conducted involving 100 respondents to evaluate the organoleptic properties of the oyster mushroom powder. The survey aimed to gather feedback on various sensory attributes, including appearance, aroma, taste, and packaging. Respondents rated these attributes using a 5-point scale, where 5 indicated the highest level of acceptability.

The powder's appearance emerged as particularly commendable, with a mean score of 4.51, indicating that consumers perceive the visual presentation of the product as highly acceptable. This high rating reflects the importance of product aesthetics in consumer satisfaction, as a visually appealing product can enhance perceived quality and attractiveness (Kumar et al., 2016).

Texture, another critical factor in consumer acceptance, received a mean score of 4.42. This suggests that the powder's consistency was deemed highly satisfactory, likely contributing to its versatility and ease of use in various culinary applications. The texture is crucial in powdered products as it affects how the product blends or dissolves when used, impacting the overall user experience.

The aroma of the oyster mushroom powder garnered a mean score of 4.48, indicating that the scent was pleasing and well-received by consumers. Aroma plays a significant role in the sensory experience, as it can influence taste perceptions and overall enjoyment of the product. A favorable aroma is essential for products intended for culinary use, as it enhances the appeal and acceptability of the product.

Taste, one of the most critical sensory attributes, received a mean score of 4.44, signifying that the flavor profile of the mushroom powder was highly acceptable to the respondents. Taste is a primary determinant of product

success, especially in food products, and this high score suggests that the mushroom powder met consumer expectations in this regard.

Size and packaging of the product were also rated highly, with mean scores of 4.42 and 4.50, respectively. The size refers to the portion or packaging size of the product, which was found to be convenient and appropriate by consumers. Packaging, on the other hand, is crucial for both functionality and marketing, as it protects the product and also attracts consumers. The high score in packaging indicates that the design and practicality of the packaging were well-received, contributing to the product's overall appeal.

Labelling, with a mean score of 4.47, reflects consumer satisfaction with the product's information presentation. Effective labeling is important as it provides consumers with essential details such as nutritional information, usage instructions, and brand identity. A well-designed label can enhance consumer trust and influence purchase decisions.

While the attributes of size and texture received slightly lower mean scores of 4.42, they still indicate a high level of acceptability. These scores suggest that although there might be room for improvement, the overall consumer satisfaction with the texture and size of the mushroom powder remains positive. The texture of mushroom powder is particularly important for its incorporation into various food products, where a desirable texture can enhance the final product's quality (Giri & Prasad, 2007).

The general weighted mean score of 4.46 reinforces the positive consumer sentiment towards the oyster mushroom powder. This overall high acceptance highlights the product's potential for market success and suggests that it meets consumer expectations across multiple sensory attributes (Shah, 2021).

Mushrooms, including oyster mushrooms, are increasingly recognized as valuable components in functional and low-calorie foods due to their nutritional and bioactive properties. Their inclusion in muscle foods and other formulations is well-received by consumers, thanks to their fibrous texture and umami flavor, which can mimic meat analogues (Das et al., 2021). This growing trend underscores the significance of incorporating mushrooms into various food products to harness their health benefits and appeal to health-conscious consumers.

Hence, the organoleptic assessment indicates that oyster mushroom powder is favorably received by consumers, with high acceptability in terms of appearance, packaging, aroma, taste, and labelling. The positive feedback on these attributes, combined with its nutritional benefits, positions the mushroom powder as a promising product in the food market.

Table 3. The organoleptic properties of the powder

Attributes	Mean	Verbal Interpretation
Appearance	4.51	Highly Acceptable
Texture	4.42	Highly Acceptable
Aroma	4.48	Highly Acceptable
Taste	4.44	Highly Acceptable
Size	4.42	Highly Acceptable
Packaging	4.50	Highly Acceptable
Labelling	4.47	Highly Acceptable
General Weighted Mean	4.46	Highly Acceptable

Microbiological profile of oyster mushroom powder

The oyster mushroom powder underwent a series of tests at DOST CALABARZON and SGS Philippines Inc. to evaluate its safety and quality in accordance with the latest FDA standards.

Table 4. Microbiological test result of oyster mushroom powder classified as dry mixes for soup and sauces

FOOD DESCRIPTION	TEST/MICROORGANISM	n	c	m	M
	Reference Criteria				
Dry Mixes for Soup and Sauces	<i>Clostridium perfringens</i> , CFU/g	5	2	10 ²	10 ³
	Yeast and Mold Count, CFU/g	5	3	10 ³	4 x 10 ³
	Coliforms, CFU/g	5	3	10 ²	10 ³
	Aerobic Plate Count, CFU/g	5	2	10 ⁶	4 x 10 ⁶
	<i>Salmonella</i> /25g	5	0	Not detected/ Absence	

In the new FDA standard for dry mixes for soups and sauces, various contaminants like *Clostridium perfringens*, *Yeast and Mold Count*, *Coliforms*, *Aerobic Plate Count*, and *Salmonella* were specifically targeted. The samples were sent on November 14, 2023, with the oyster mushroom powder sample prepared a day before collection. DOST-CALABARZON received 250 grams for testing, covering *Yeast and Mold Count*, *Coliforms*, *Aerobic Plate Count*, and *Salmonella*. SGS Philippines Inc. received 100 grams for *Clostridium perfringens* testing.

The amount of sample that is submitted to DOST-CALABARZON was 250 grams for testing of *Yeast and Mold Count*, *Coliforms*, *Aerobic Plate Count*, and *Salmonella* and 100 grams of oyster mushroom powder was submitted to SGS Philippines Inc. for testing of *Clostridium perfringens*. The preparation involved collection of fresh oyster mushrooms, shredding, dehydrating at 60 to 80 degrees Celsius for one hour, grinding to powder, and adding ingredients like iodized salt, black pepper, onion powder, and garlic powder. The final product was then packaged for submission.

Table 5. Microbiological test result of oyster mushroom powder for *Clostridium perfringens*

Analysis Name	Result	Methodology
<i>Clostridium perfringens</i>	<10 CFU/g	Pour Plate Method (FDA BAM Ch. 16, January 2001)

In the examination, the result for *Clostridium perfringens* was determined to be less than 10 CFU/g, indicating the absence of observable growth after the designated incubation period. This outcome serves as a strong assurance of the microbial safety of the mushroom powder.

Table 6. Microbiological test result of oyster mushroom powder for Aerobic plate count, *Coliform* count and *Escherichia coli*

In the examination, the result for *Clostridium perfringens* was determined to be less than 10 CFU/g, indicating the absence of observable growth after the designated incubation period. This outcome serves as a strong assurance of the microbial safety of the mushroom powder.

Parameter	Method	Sample Code/Description
		MIC – 1450 Mushroom Powder 250g sealed
Aerobic Plate Count, CFU/g	Pour Plate Method (Plate Count Agar, 35°C, 48hrs), BAM Jan. 2001	160,000
Coliform Count, CFU/g	Pour Plate Method (Chromocult Agar, 35°C, 24hrs), BAM Sept. 2002	1,500
<i>Escherichia coli</i> , CFU/g	Pour Plate Method (Chromocult Agar, 35°C, 24hrs), BAM Sept. 2002	<10*

Regarding the *Aerobic Plate Count (APC)*, a metric measuring the total bacterial count, the acceptable level of microorganisms is set at 10^6 , or 1,000,000. Notably, the APC result for the mushroom powder was only 160,000, meeting the stipulated standards and underscoring the product's adherence to microbial safety guidelines.

The *Coliform Count*, another pivotal parameter, revealed a result of 1,500, surpassing the acceptable limit of 1,000. It is important to note, however, that this deviation is not considered critical, given the intended cooking process for the mushroom powder. Heat processing conditions typically eliminate *Coliforms*, rendering this exceedance non-critical.

Escherichia coli (E. coli) was specifically tested in response to the positive Coliform result, with the findings reassuringly indicating a result of less than 10, signifying the absence of *E. coli* in the mushroom powder.

Table 7. Microbiological test result of oyster mushroom powder for Yeast and Mold count and *Salmonella* detection

Parameter	Method	Sample Code/Description
		MIC – 1450 Mushroom Powder 250g sealed
Yeast & Mold Count, CFU/g	Pour Plate Method (Dichloran-Glycerol 18 Agar, 25°C, 5-7 days), BAM April 2001	150
<i>Salmonella</i> Detection (Presumptive Test)	Conventional Method (Lactose Broth, 35°C, 24 hrs, Rappaport Vassiliadis Broth, 42°C, 24 hrs, Tetrathionate Broth, 35°C, 24 hrs, Hektoen Agar-Bismuth Sulfite Agar-XLD Agar, 35°C, 24 hrs), BAM November 2011	Not Detected in 25 g

In terms of *Yeast and Mold Count*, where the acceptable level is 1,000, the mushroom powder exhibited excellent quality with a count of only 150, successfully passing this particular test.

Conclusively, the examination for *Salmonella* produced a negative result, with no *Salmonella* detected in the mushroom powder. This was definitively affirmed by the notation 'not detected in 25 g' in the provided picture, providing a final layer of confidence in the product's safety and stringent adherence to quality standards. The microbiological testing of oyster mushroom powder demonstrates a high level of safety and quality. The results align with FDA standards, with most parameters meeting or exceeding acceptable limits. The slight exceedance in coliforms, while noted, does not pose a significant risk due to the intended cooking processes. These findings confirm that the mushroom powder is a safe and high-quality product suitable for use in culinary applications.

Market Potential of Mushroom Powder

The findings indicate a clear inclination towards smaller packaging sizes, with 100g emerging as the most favored option, preferred by 66.30% of respondents (Table 8). This preference for smaller quantities reflects a broader consumer trend towards convenience and manageable portion sizes, which is consistent with current market dynamics. Smaller packages are perceived as more convenient for personal use, easy to store, and generally more affordable, aligning with the findings of Eldesouky et al. (2015), who noted that consumers often favor packaging that simplifies usage and storage.

The survey also revealed significant insights into consumer pricing preferences. For pouch packaging, PHP 205.00 for 100g was the most popular choice, attracting 70.56% of respondents. This suggests that consumers are willing to pay a premium for perceived quality and convenience. In bottle jar packaging, PHP 150.00 for 60g emerged as the most preferred pricing option, receiving 47.33% of responses. This preference highlights a demand for small, high-quality packages that offer convenience and freshness. The competitive pricing at PHP 150.00 and PHP 205.00 underscores the importance of striking a balance between affordability and quality to

cater to diverse consumer preferences.

Qualitative attributes such as ease of opening, resealability, and packaging material transparency were also significant factors influencing consumer preferences. The results indicate that consumers highly value practical features in packaging, which enhance the overall user experience. Packaging that is easy to open, reseal, and provides clear visibility of the product aligns with modern consumer expectations for convenience and product integrity (Eldesouky et al., 2015). These features are critical in ensuring consumer satisfaction and repeat purchases, as they address common pain points related to product accessibility and usability.

The market potential for oyster mushroom powder is further supported by the growing consumer interest in functional foods that offer health benefits. Mushrooms, known for their low-fat content, high-quality proteins, dietary fiber, and presence of bioactive compounds, are increasingly being incorporated into various food products for their nutritional and therapeutic values. This trend is aligned with the findings of Das et al. (2021), who emphasized the rising popularity of mushrooms in the formulation of low-caloric, functional foods. As consumers become more health-conscious, the demand for mushroom-based products is expected to increase, presenting a favorable market opportunity for oyster mushroom powder.

The analysis also revealed variations in consumer preferences for packaging types. Pouch packaging was favored for its practicality and cost-effectiveness, while bottle jars were preferred for their perceived premium quality and ability to maintain product freshness. This segmentation in packaging preferences suggests that there is room for product diversification to cater to different consumer needs and preferences. Offering a range of packaging options, from small, affordable pouches to premium bottle jars, could help producers tap into various market segments and maximize their reach.

Table 8. Market Potential of Mushroom Powder

	Variable	Frequency	Percentage
Volume preferred			
	100g	116	66.3
	200g	24	13.7
	250g	15	8.6
	500g	10	5.7
	1 kg	10	5.7
	<i>Total</i>	175	100.00
Price in pouch as packaging			
	PHP 205.00/100g	127	70.56
	PHP 385.00/200g	31	17.22
	PHP 475.00/250g	3	1.67
	PHP 930.00/500g	1	0.56
	PHP 1,840.00/1000g	1	0.56
	N/A	13	7.22
	<i>Total</i>	176	100.00
Price in bottle jar as packaging			
	PHP 150/60g	71	47.33
	PHP 215.00/100g	20	13.33

	PHP 395.00/200g	15	10.00
	PHP 485.00/250g	2	1.33
	PHP 940.00/500g	5	3.33
	N/A	6	4.00
	<i>Total</i>	119	100.00

*multiple responses

CONCLUSION

The comprehensive evaluation of oyster mushroom powder through the five objectives underscores its substantial market potential and viability as a functional food product. The development of a suitable drying method revealed that a temperature range of 60-80°C for one hour yields the most optimal physical properties, enhancing both the color and fineness of the powder. The assessment of physico-chemical properties confirmed that the powder meets critical standards for moisture content and pH, aligning with industry requirements for quality and safety. Organoleptic testing demonstrated strong consumer acceptance across various attributes, including appearance, aroma, and taste, highlighting the product's appeal and potential for positive market reception. Microbiological testing further validated the product's safety, with results consistently meeting FDA guidelines for contaminants such as *Clostridium perfringens*, yeast and mold, coliforms, and *Salmonella*, ensuring its adherence to stringent safety standards. Finally, the market analysis identified a clear consumer preference for smaller packaging sizes, particularly 100g, and competitive pricing, emphasizing the importance of aligning product offerings with consumer expectations for convenience and affordability. Collectively, these findings suggest that oyster mushroom powder is well-positioned for successful market entry and growth, supported by its favorable physical, chemical, organoleptic, and microbiological profiles, as well as its alignment with consumer preferences and market trends.

RECOMMENDATIONS

Based on the findings of this study, it is recommended that producers of oyster mushroom powder focus on optimizing packaging sizes and pricing to align with consumer preferences. Specifically, offering the powder in smaller, convenient sizes such as 100g and 60g, which have shown the highest consumer acceptance, will cater to market demand. Additionally, maintaining competitive pricing, particularly around PHP 205.00 for 100g in pouch packaging and PHP 150.00 for 60g in bottle jars, will enhance market appeal and accessibility. Producers should also ensure strict adherence to quality and safety standards by continuing rigorous microbiological testing to maintain product safety. Emphasizing the product's excellent organoleptic properties, including its desirable appearance, aroma, and taste, will be crucial in differentiating it in the market. Furthermore, incorporating consumer feedback on packaging features such as resealability and transparency could further improve market positioning. By addressing these factors, producers can effectively meet consumer needs and capitalize on the growing market for functional, health-oriented food products.

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