

Fish Bone Analysis Toward Risk Mitigation of Mushroom Cultivation

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Abstract

Oyster mushroom cultivation has considerable economic potential; however, production activities are inherently exposed to various risks that may disrupt productivity and business sustainability. UD. ARERA Oyster Mushroom in East Denpasar faces recurring production risks, including inconsistent baglog quality, unstable temperature and humidity conditions in the mushroom house, limited worker skills, and pest infestations. These conditions necessitate a structured and systematic risk management approach. This study aims to identify production risks, analyze their root causes, and formulate priority risk mitigation strategies to support business sustainability. This study employs a descriptive research design using qualitative and quantitative approaches. Primary data were collected through direct observation, in-depth interviews, and questionnaires administered to the owner and workers of UD. ARERA Oyster Mushroom. Risk identification was conducted using the Fishbone Diagram to classify root causes based on human, material, method, machine, and environmental factors. Risk prioritization was carried out using the House of Risk (HOR) method. HOR 1 was applied to determine priority risk agents based on Aggregate Risk Potential (ARP), while HOR 2 prioritized mitigation actions by evaluating effectiveness and implementation difficulty. The results indicate that the most critical production risks are inconsistent baglog quality, unstable environmental conditions, inadequate worker skills, and pest attacks. Priority mitigation strategies include establishing baglog quality standards, improving environmental control systems, providing technical training, and implementing regular pest management. The integration of Fishbone Diagram and House of Risk provides a comprehensive framework for proactive risk management in oyster mushroom cultivation.

Keywords: Agribusiness, Fishbone, House of Risk, Oyster Mushroom, Risk Management

1. Introduction

In the agricultural subsector, horticulture is one of the fields with strong development prospects, supported by the diversity of plant varieties with significant economic value when managed using appropriate cultivation techniques. Increasing public awareness of healthy lifestyles has contributed to the growing demand for horticultural products, particularly vegetables. This condition has encouraged the expansion of mushroom cultivation, which is increasingly favored due to its high nutritional content and health benefits (Djuwendah & Septiarini, 2017). Oyster mushrooms (*Pleurotus* sp.) are among the most economically valuable edible mushrooms and have been widely cultivated in various regions of Indonesia (Enshasy et al., 2015). Several commonly cultivated types include white oyster mushrooms (*Pleurotus ostreatus*), pink oyster mushrooms (*Pleurotus flabellatus*), grey oyster mushrooms (*Pleurotus sajor-caju*), and abalone mushrooms (*Pleurotus cystidiosus*) (Dibisono et al., 2023). Beyond serving as a food source, oyster mushrooms are recognized as horticultural commodities with dual functions, namely as a food products and nutraceuticals with beneficial properties.

In practice, oyster mushroom cultivation faces various challenges that may hinder business sustainability. Producers frequently encounter limitations in the availability of production inputs, particularly due to climatic variations that affect the quality of baglogs supplied by producers as well as



the stability of the growing-house environment. These conditions result in fluctuations in production output, both in terms of quantity and quality, which ultimately affect the ability of businesses to respond to market demand. Furthermore, selling price volatility driven by market dynamics increases the level of business uncertainty. Collectively, these conditions indicate the presence of production and market risks that require appropriate management strategies to ensure the sustainable operation of oyster mushroom cultivation enterprises.

UD. ARERA Jamur Tiram is a business entity engaged in oyster mushroom cultivation and is located in East Denpasar. High consumer demand for fresh oyster mushrooms in Denpasar City and its surrounding areas indicates considerable market potential for the development of this enterprise. Nevertheless, in its operational activities, UD. ARERA faces several challenges that may threaten business continuity. One of the main constraints is the instability in the supply of baglog raw materials due to inconsistent deliveries from suppliers. In addition, production environments that are highly sensitive to weather conditions adversely affect mushroom growth, resulting in suboptimal production outcomes. Beyond these issues, oyster mushroom cultivation at UD. ARERA is also exposed to risks associated with pest infestations. Based on field observations, several pests, such as caterpillars that damage baglogs, rats that disturb incubation rooms, and ants that attack mushrooms during early growth stages, frequently cause losses.

Such pest attacks may reduce both the quality and quantity of harvested products and can even lead to complete production failure if not properly managed (Bellettini et al., 2018). These conditions demonstrate that oyster mushroom cultivation involves a relatively high level of uncertainty, particularly from production and environmental perspectives. Therefore, the implementation of well-planned and systematic risk management is essential to ensure that potential risks can be effectively identified, analyzed, and controlled (Dou et al., 2025). Effective risk management is expected to minimize potential losses, maintain production stability, and support business sustainability. Accordingly, research on risk management at UD. ARERA Jamur Tiram in East Denpasar is necessary to identify the types of risks faced, their underlying causes, and appropriate risk management strategies that can enhance business resilience.

Despite the growing development of oyster mushroom cultivation in Indonesia, studies examining risk management in small- and medium-scale mushroom enterprises remain limited, particularly those applying a structured and quantitative risk assessment approach at the operational level. Previous research has generally focused on cultivation techniques, productivity improvement, or economic feasibility, while comprehensive identification of production risks and their causal factors has received less attention. Moreover, risk management practices in mushroom cultivation are often implemented reactively rather than systematically, resulting in recurring production disruptions and business uncertainty. This gap highlights the need for an analytical framework capable of identifying priority risk agents and determining appropriate mitigation strategies based on their level of impact and occurrence. Therefore, this study aims to analyze production risks in oyster mushroom cultivation at UD. ARERA Jamur Tiram using a structured risk management approach, to identify dominant risk agents and formulate effective mitigation strategies that support production stability and long-term business sustainability.

2. Methods

2.1. Research Design and Location

This study employed a case study approach using a combination of qualitative and quantitative descriptive methods. The research was conducted at UD. ARERA Jamur Tiram, an oyster mushroom

cultivation enterprise located in East Denpasar, Bali. The research site was selected purposively based on the consideration that the enterprise is still experiencing various production-related problems and has not previously been examined in studies on risk management. The study was carried out from November to December 2025.

2.2. Data Collection

The data used in this study consisted of primary and secondary data. Primary data were obtained through direct observation, in-depth interviews, and the distribution of questionnaires to respondents involved in the production process. Secondary data were collected from company documents, production records, and relevant literature related to risk management and oyster mushroom cultivation.

2.3. Respondents

The respondents consisted of five individuals, comprising one business owner and four workers. All respondents were selected because they were directly involved in the oyster mushroom production process and were considered to have adequate knowledge of the risks encountered during cultivation activities.

2.4. Risk Analysis Method

Risk analysis in this study was conducted in two main stages: Fishbone Diagram analysis and House of Risk (HOR) analysis. The Fishbone Diagram was applied to identify the root causes of production risks, while the House of Risk method was used to determine risk priorities and formulate mitigation strategies.

1. Fishbone Diagram Analysis

The first stage focused on identifying the underlying causes of production risks in oyster mushroom cultivation based on actual conditions at UD ARERA Jamur Tiram. The main problem identified from field observations was declining productivity and unstable harvest yields.

Potential contributing factors were obtained through direct observation and interviews with the business owner and workers. The identified risks included inconsistent baglog quality supplied by vendors, inadequate cultivation room ventilation, unstable humidity conditions, limited technical training for workers, and pest infestations.

These causes were subsequently classified using the 6M framework, consisting of human resources, methods, machinery, materials, environment, and management aspects. Based on this classification, a Fishbone Diagram was developed to illustrate the relationship between production problems and their root causes according to field analysis results.

2. House of Risk (HOR) Analysis

The second stage employed the House of Risk (HOR) method, which consists of two phases: HOR Stage 1 and HOR Stage 2.

a. House of Risk Stage 1 (HOR 1)

HOR Stage 1 aimed to identify risk events (RE) and risk agents (RA) and determine priority risks. Risk events refer to conditions that may disrupt oyster mushroom production, while risk agents represent factors causing those events.

Each risk event was evaluated using a severity score (S) based on its impact on production performance, product quality, and harvest continuity using a five-point scale (1–5). Risk agents were assessed using an occurrence score (O) reflecting the frequency of occurrence during production activities, obtained through questionnaires distributed to knowledgeable respondents using a five-point scale (1–5).

The relationship between risk events and risk agents (R_{ij}) was assessed using a correlation matrix with the following values:

0 = no relationship

1 = low relationship

3 = moderate relationship

9 = strong relationship

The Aggregate Risk Potential (ARP) value was calculated to determine priority risk agents by combining severity, occurrence, and correlation values (R_{ij}) for each risk agent (Fole, 2023). ARP values were then compiled into the HOR₁ table to establish risk priorities.

b. House of Risk Stage 2 (HOR₂)

HOR Stage 2 aimed to determine effective mitigation strategies for priority risks identified in HOR Stage 1. Alternative mitigation actions were formulated based on risk agents with the highest ARP values.

Each mitigation strategy was evaluated based on its effectiveness (E) in reducing risk impacts using a five-point scale (1–5). In addition, the implementation difficulty (D) was assessed by considering cost requirements, time requirements, technical expertise, and resource availability using a five-point scale consistent with the HOR methodology. The Effectiveness-to-Difficulty Ratio (ETD) was calculated using the following formula (Oktavera et al., 2022):

$$ETD_k = \frac{\sum (AR_i \times E_{ik})}{D_k}$$

The results were compiled into the HOR₂ table, and mitigation strategies with the highest ETD values were selected as priority recommendations for implementation at UD ARERA Jamur Tiram.

3. Results and Discussion

3.1. Identification of Production Risks

Production risk identification was conducted based on field observations, interviews with the business owner and workers, and questionnaire responses. The results indicate that oyster mushroom cultivation at UD. ARERA Jamur Tiram faces various production risks that may disrupt yield stability. These risks include declining production volume, inconsistent mushroom quality, baglog contamination, pest infestations, and suboptimal growing-house conditions. Such risks directly affect production continuity and the enterprise's ability to consistently meet market demand. This finding is consistent with Iswari et al. (2025), who reported that production risk is the dominant risk in oyster mushroom enterprises and significantly influences business sustainability.

3.1.1. Analysis of Risk Causes Using Fishbone Diagram

The Fishbone Diagram analysis was used to identify the root causes of production risks by grouping contributing factors into six main aspects: human resources, methods, machinery, materials, environment, and management.

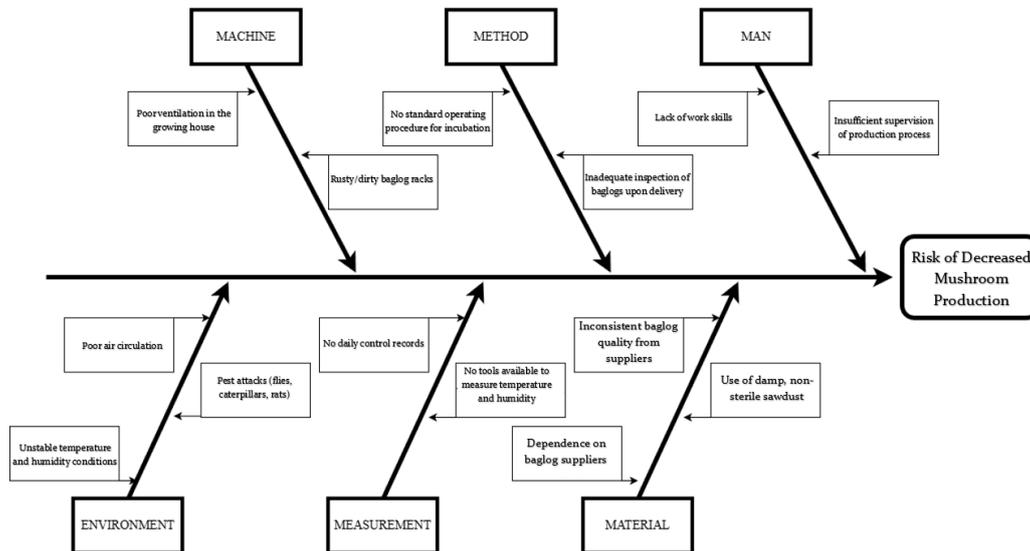


Figure 1. Fishbone Diagram of Production Risk Causes in Oyster Mushroom Cultivation at UD. ARERA Jamur Tiram

As illustrated in Figure 1, oyster mushroom production risk is influenced by multiple interrelated factors that collectively affect production performance. The analysis reveals that the dominant causes of production risk include inconsistent baglog quality supplied by external producers, inadequate control of temperature and humidity in the growing house, and limited technical skills among workers. In addition, environmental factors such as weather fluctuations and pest attacks further contribute to production risk. Consistent with Hariyanto et al. (2021), who found that unfavorable environmental conditions and pest infestations are major factors leading to reduced oyster mushroom productivity.

3.1.2. Risk Prioritization Using House of Risk (HOR 1)

The first stage of the House of Risk (HOR) analysis is applied to determine the priority risk agents that have the most significant influence on the occurrence of production risks in oyster mushroom cultivation at UD. ARERA Jamur Tiram. This stage focuses on identifying risk agents with the highest contribution to production risks, so that the results can be used as a basis for formulating appropriate mitigation strategies in the subsequent stage. In HOR Stage 1, the analysis integrates the identification of risk events and risk agents. Each risk event is evaluated based on its level of severity, while each risk agent is assessed according to its frequency of occurrence. These assessments are obtained through questionnaires completed by respondents, thereby reflecting the actual conditions encountered in the oyster mushroom production process.

Table 1. Assessment of Risk Event Severity

Aspect	Code	Risk Event	Severity (Si)
Oyster	E1	Failure of baglog growth	3,4
Mushroom	E2	Contamination of baglog by wild fungi	4,0
Production	E3	Unstable humidity in the mushroom house	3,0
	E4	Mushroom house temperature is too high/too low	3,4
	E5	Rapid spoilage of mushrooms after harvest	2,4
	E6	Inconsistent production between cycles	2,4
	E7	Delay in the harvesting process	2,8
	E8	Delay in distribution to consumers	1,4
	E9	Pest attacks on mushrooms	4,4

Source: Primary Data Processed by the Author, 2025

The results of the severity assessment for each production risk event indicate that several risk events have relatively high severity levels. This condition suggests that if these risks occur, they may cause significant impacts on both the quantity and quality of oyster mushroom yields. Therefore, risk events with high severity values should be prioritized in the subsequent stages of risk analysis.

Table 2. Assessment of Risk Event Occurrence

Aspect	Code	Risk agent	Occurrence (Oj)
Man	A1	Lack of technical training in mushroom cultivation	2,8
	A2	Irregular monitoring of the production process	2,6
Machine	A3	Suboptimal ventilation in the mushroom house	2,8
	A4	Rusty or dirty baglog racks	3,0
Material	A5	Inconsistent quality of baglog supplied by suppliers	2,4
	A6	Dependence on baglog suppliers	3,0
Method	A7	Inadequate quality inspection of baglog upon receipt	2,2
	A8	Incubation process not conducted according to standard procedures	2,2
Measurement	A9	Absence of automatic temperature and humidity measuring devices	2,6
	A10	Lack of daily control record-keeping	2,2
Environment	A11	Excessive humidity in the mushroom house	2,0
	A12	Frequent temperature fluctuations in the mushroom house	3,2
	A13	Insect pest attacks on mushrooms (ants and caterpillars)	3,2

Source: Primary Data Processed by the Author, 2025

The results of the occurrence assessment indicate that the risk agents with the highest frequency are fluctuations in cultivation room temperature (A12) and insect pest attacks on oyster mushrooms (A13), each with an occurrence value of 3,2. These findings suggest that both risk agents occur relatively frequently and have the potential to trigger various production risks, particularly those related to instability in the cultivation environment and physical damage to the mushrooms.

Table 3. Correlation Matrix of Risk Agents to Risk Events (R_{ij})

Risk Agent	Risk Event	E1 Failure of baglog growth	E2 Contamination of baglog by wild fungi	E3 Unstable humidity in mushroom house	E4 Mushroom house temperature too high/low	E5 Rapid spoilage after harvest	E6 Inconsistent production between cycles	E7 Delay in harvesting	E8 Delay in distribution	E9 Pest attacks on mushrooms
A1	Lack of technical training	3	3	1	1	3	3	3	0	1
A2	Irregular supervision	3	3	3	3	3	3	3	1	1
A3	Suboptimal ventilation	3	3	9	9	1	3	0	0	1
A4	Rusty or dirty baglog racks	1	3	1	1	1	1	0	0	1
A5	Inconsistent baglog quality	9	3	1	1	1	9	0	0	0
A6	Dependence on baglog suppliers	1	0	0	0	0	3	0	0	0

A7 Weak baglog inspection	9	3	1	1	1	3	0	0	0
A8 Incubation not in accordance with SOPs	9	3	3	3	1	3	1	0	0
A9 Absence of measuring devices	1	1	9	9	1	3	0	0	0
A10 Lack of daily control record-keeping	1	1	3	3	1	3	1	0	0
A11 Excessive humidity	3	9	9	3	1	3	0	0	3
A12 Frequent temperature fluctuations	3	1	3	9	1	3	0	0	1
A13 Insect pest attacks on mushrooms	1	3	0	0	1	1	0	0	9

Source: Primary Data Processed by the Author, 2025

Based on the results of the correlation matrix analysis between risk agents and risk events, it is found that several risk agents exhibit a high level of association with specific risk events. One of the risk agents showing the strongest relationship is suboptimal cultivation room ventilation, which has a very high correlation value (9) with humidity instability (E3) and temperature instability in the cultivation room (E4). These findings indicate that ventilation management plays a critical role in maintaining environmental stability, which is a key factor in the success of oyster mushroom production.

Table 4. Determination of Aggregate Risk Potential (ARP) Value

Code	Risk Agent	Occurrence (O)	$\Sigma (S \times R)$	ARP	Category
A12	Frequent temperature fluctuations in the mushroom house	3.2	82.5	264.0	Priority
A5	Inconsistent baglog quality	3.0	85.3	256.0	Priority
A11	Excessive humidity in the mushroom house	3.0	80.0	240.0	Priority
A3	Suboptimal ventilation in the mushroom house	3.5	64.0	224.0	Priority
A9	Absence of temperature and humidity measuring devices	3.2	65.0	208.0	Priority
A2	Irregular production supervision	3.0	48.0	144.0	Medium
A1	Lack of technical training	2.8	40.7	114.0	Medium
A8	Incubation process not in accordance with SOPs	2.2	42.0	92.4	Low
A13	Pest attacks	2.5	38.4	96.0	Low
A7	Inadequate baglog quality inspection	2.2	30.0	66.0	Low
A10	Lack of daily control record-keeping	2.2	28.0	61.6	Low
A4	Rusty or dirty baglog racks	2.0	24.0	48.0	Low
A6	Dependence on baglog suppliers	2.2	16.0	35.2	Low

Source: Primary Data Processed by the Author, 2025

The results of the Aggregate Risk Potential (ARP) calculation indicate variations in ARP values across different risk agents. These differences reflect that each risk agent contributes to production risks in oyster mushroom cultivation at UD. ARERA Jamur Tiram to a different extent. Risk agents with

higher ARP values represent greater overall risk potential and therefore require higher priority in risk management and mitigation efforts.

Based on the results of the House of Risk Stage 1 (HOR 1) analysis, several risk agents with relatively high Aggregate Risk Potential (ARP) values were identified, indicating the need for special attention in managing oyster mushroom production risks at UD. ARERA Jamur Tiram. The highest-priority risk agent is humidity instability in the cultivation room, followed by inconsistent baglog quality from suppliers and limited technical training for workers. The high ARP value associated with humidity instability indicates that environmental conditions play a significant role in determining the success of oyster mushroom cultivation. Biologically, oyster mushrooms are highly sensitive to changes in humidity levels. Humidity below the optimal range can inhibit fruiting body formation, while excessive humidity may increase the risk of contamination and disease outbreaks. Consequently, disturbances in environmental factors directly lead to a decline in both the quantity and quality of mushroom yields.

The findings of this study are consistent with those of Hariyanto et al. (2021), who stated that the inability to control cultivation room environmental conditions is one of the main factors contributing to decreased oyster mushroom productivity. However, the results of this study differ from those reported by Iswari et al. (2025), who identified pest attacks as the most dominant production risk. These differences are likely influenced by variations in business characteristics, production systems, as well as local environmental and climatic conditions across study locations.

3.1.3. Risk Mitigation Strategies Using House of Risk (HOR 2)

In contrast to House of Risk Stage 1 (HOR 1), which focuses on identifying and prioritizing risk agents, House of Risk Stage 2 (HOR 2) is directed toward formulating preventive actions to control the sources of risk. This approach emphasizes that risk management is more effective when it concentrates on controlling risk agents at an early stage rather than addressing the impacts after risks have already occurred.

Table 5. Preventive Action (PA)

Code	Preventive Action (PA)
PA1	Installation of thermometers and hygrometers in the mushroom house
PA2	Development of SOPs for temperature and humidity control
PA3	Selection and evaluation of baglog suppliers
PA4	Regular monitoring of environmental conditions in the mushroom house
PA5	Improvement and optimization of mushroom house ventilation
PA6	Periodic pest control

Source: Primary Data Processed by the Author, 2025

The proposed mitigation actions are expected to sustainably reduce the likelihood of production risks by addressing the underlying risk agents, provided that they are implemented consistently.

Table 6. Determination of Risk Mitigation Priorities using the Effectiveness to Difficulty Ratio (ETD)

Preventive Action (PA)	Frequent temperature fluctuations in the mushroom house	Inconsistent baglog quality	Excessive humidity in the mushroom house	Suboptimal ventilation in the mushroom house	Absence of temperature and humidity measuring devices	Total Effectiveness	Difficulty (D)	Effectiveness-to Difficulty Ratio (ETD)
Installation of thermometers and hygrometers in the mushroom house	9	1	9	3	9	31	2	15,5
Development of standard operating procedures for temperature and humidity control	9	1	9	3	3	25	2	12,5
Selection and evaluation of baglog suppliers	1	9	1	1	0	12	3	4,0
Regular monitoring of environmental conditions in the mushroom house	9	1	9	3	3	25	2	12,5
Improvement and reorganization of mushroom house ventilation	9	0	9	9	1	28	4	7,0
Periodic pest control	1	1	3	1	0	6	2	30

Source: Primary Data Processed by the Author, 2025

The results of the Effectiveness to Difficulty Ratio (ETD) calculation indicate that the installation of thermometers and hygrometers in the cultivation room has the highest ETD value, and is therefore prioritized as the primary mitigation strategy. This action is considered effective in maintaining stable

temperature and humidity conditions in the cultivation room, which are critical factors supporting successful oyster mushroom production.

The results of the House of Risk Stage 2 (HOR 2) analysis indicate that mitigation strategies with the highest Effectiveness to Difficulty Ratio (ETD) include controlling cultivation room humidity through routine monitoring and improvements to the ventilation system, followed by the establishment of quality standards for baglogs supplied by vendors and enhanced technical training for workers. These strategies are considered effective in reducing production risks while remaining feasible within the capacity of UD. ARERA Jamur Tiram as a small-scale enterprise. The findings suggest that effective production risk management does not necessarily require high technological investment, but can be achieved through the consistent implementation of simple technical management practices. Regular humidity monitoring, adjustment of watering schedules, and improvement of air circulation within the cultivation room represent preventive actions that are relatively easy to implement yet have a significant impact on maintaining production stability. These strategies are prioritized because they directly target the main risk agents identified in HOR Stage 1.

The findings of this study are consistent with those of Maryan et al. (2024), who stated that in small-scale oyster mushroom enterprises, the implementation of simple but disciplined technical management practices is more effective than development strategies requiring substantial resources. Accordingly, this study reinforces that risk mitigation strategies should be aligned with the capabilities and characteristics of the enterprise in order to ensure sustainable implementation.

4. Conclusion

Based on the results of the study, oyster mushroom production at UD. ARERA Jamur Tiram in East Denpasar faces several production risks originating from environmental conditions, raw material quality, labor competence, and pest attacks. The main risks include unstable temperature and humidity in the cultivation room, inconsistent baglog quality from suppliers, limited technical skills of workers, and pest infestations such as caterpillars, ants, and rats, all of which may reduce production quantity and quality. Current risk management practices are still relatively simple and tend to be reactive, as mitigation efforts such as manual watering regulation, routine cleaning, and pest control are not yet supported by standardized operating procedures.

Based on the Fishbone Diagram and House of Risk (HOR) analysis, several strategies are recommended to minimize production risks, including regular monitoring and control of temperature and humidity, establishment of quality standards for baglog suppliers, improvement of workers' technical skills through training, and implementation of routine pest control measures. Small-scale enterprises such as UD. ARERA Jamur Tiram are encouraged to adopt more structured and preventive risk management practices, particularly through the development of standard operating procedures (SOPs), improved environmental control systems, and continuous workforce capacity development to enhance production stability and business sustainability.

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