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Mitigating Supply Chain Risks in The Traditional Beverage Industry with The House of Risk (HOR) Method

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Abstract. *The production process of wedang uwuh at MSMEs XYZ frequently encounters interruptions caused by a scarcity of raw materials from a limited supplier base. This research employs the House of Risk (HOR) method to identify risks, prioritize risk agents, and formulate mitigation solutions. During the initial phase of HOR, 27 risk events and 30 risk agents were found, with 15 priority risk agents determined by a cumulative Aggregate Risk Potential (ARP) value of 81%. During the second phase of HOR, 24 mitigation strategies were developed, with the foremost five being: (PA14) routine equipment inspection and maintenance; (PA1) systematic sales documentation; (PA4) partnership with large farmers/suppliers; (PA11) standard operating procedures in the mixing process; and (PA13) formulation of adaptable contracts with suppliers concerning volume and delivery timelines. The execution of these mitigation techniques is anticipated to improve operational efficiency and supply chain resilience at XYZ MSMEs in addressing current concerns.*

Keywords: *aggregate risk potential; house of risk; supply chain; traditional beverage.*

I. INTRODUCTION

The micro, small, and medium enterprises (MSMEs) sector is pivotal in Indonesia's economy. Micro, small, and medium enterprises (MSMEs) contribute to economic expansion, generate employment, and alleviate poverty (Bălu, 2021). Wedang uwuh, a traditional Indonesian herbal beverage, is gaining popularity due to its numerous health advantages. This product comprises natural materials, including cloves, nutmeg leaves, and cinnamon, embodying cultural values and considerable commercial possibilities (Setyowati et al., 2023).

MSMEs XYZ participates in the traditional beverage sector, manufacturing a range of goods, including wedang uwuh, red ginger, temulawak, and turmeric. Wedang uwuh is the flagship product due to significant consumer demand. Nonetheless, this MSME encounters numerous hazards in its production process that could hinder the seamless functioning of the business, encompassing issues related to raw materials and the distribution of the final product to consumers.

Several key risks commonly faced by MSMEs, such as MSMEs XYZ, include inaccurate market demand forecasting, difficulties in raw material inventory planning, stock shortages, substandard raw material quality, a limited number of suppliers, and machinery breakdowns due to the absence of regular maintenance schedules. These risks often result in delays in the production process, ultimately affecting the overall performance of the supply chain. Therefore, systematic efforts are needed to identify and address these risks to ensure the sustainability and improvement of the MSMEs supply chain performance.

This research is crucial because supply chain risks can disrupt the operational stability of MSMEs, which generally have more limited resources than larger companies (Mamun, 2023). Moreover, wedang uwuh a traditional beverage product, has significant domestic and international market potential, particularly with the growing public awareness of healthy lifestyles (OECD, 2024). By identifying risks and designing effective mitigation strategies, MSMEs XYZ can enhance supply chain efficiency, maintain product quality, and strengthen its competitiveness in the market.

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The House of Risk (HOR) method has been applied in various manufacturing industries to analyze and mitigate supply chain risks. Previous studies have used HOR in the bag-making industry (Nugraha et al., 2023), military and heavy equipment (Liansari et al., 2020), potato production (Syamsiyah et al., 2024), corn supply chains (Zuhri et al., 2024), and Ready-To-Drink (RTD) beverage manufacturing (Nugraheni, 2017). These studies identified potential risks, prioritized risk agents using Aggregate Risk Potential (ARP) scores, and proposed mitigation strategies. However, studies have yet to utilize HOR in the traditional beverage industry.

Given the significant role of the micro and small industries (IMK) in Indonesia's economy, including the traditional beverage sector, research on supply chain risks in this sector is critical. Micro and small industries, which contribute substantially to employment and income distribution, still face challenges related to capital, raw material distribution, and simple technology (Badan Pusat Statistik, 2023). Therefore, research employing the HOR method in the traditional beverage industry can provide deeper insights into the specific risks faced by this sector and help develop more effective mitigation strategies.

Improving and measuring supply chain performance will be beneficial when used as a basis for implementing improvements (Anisatussariroh, 2024). A common approach to enhancing supply chain performance involves mapping the existing supply chain processes and defining the desired ideal conditions. One framework that can be used to measure and improve supply chain performance is the Supply Chain Operations Reference (SCOR) model. This model encompasses five primary dimensions: planning, sourcing, production, distribution, and returns (Kusrini et al., 2019).

A more specific approach is needed to identify, analyze, and mitigate the various risks in the supply chain of MSMEs such as MSMEs XYZ. The SCOR (Supply Chain Operations Reference) model and the House of Risk (HOR) method are possible approaches. The HOR method provides a systematic framework that helps identify risk sources and prioritizes mitigation actions based on the severity and likelihood of risks occurring (Pujawan & Geraldin, 2009). With this approach, MSMEs can develop more effective and efficient risk mitigation strategies (Wibowo & Ahyudanari, 2021).

This study aims to identify risks and risk sources in MSMEs XYZ's supply chain and determine mitigation action priorities. The results of this study are expected to provide recommendations for mitigation strategies ranging from simple to more complex implementations. By applying appropriate mitigation strategies, MSMEs XYZ is anticipated to reduce potential risks, minimize losses, and enhance business stability and customer confidence in product quality.

II. RESEARCH METHOD

Comprehensive assessment of each activity is performed to ascertain potential hazards, concentrating on the wedang uwuh manufacturing process, which encompasses planning, sourcing, production, delivery, and return (Tang, 2006). This study employs a questionnaire meticulously crafted through a systematic methodology to guarantee the dependability of the collected data (Creswell, 2009). The selection of responders for the questionnaire is predicated on their proficiency in evaluating potential hazards and their corresponding mitigation techniques. The chosen respondents are the production manager and the proprietor of MSMEs XYZ. This study was conducted over two months, from October to November 2024. The comprehensive data collecting and processing protocols are outlined as follows:

Phase 1 House of Risk (HOR)

This study used the House of Risk (HOR) measuring approach. HOR comprises two primary phases: Phase 1 concentrates on evaluating the severity of risk events, analyzing risk agents, and determining the relationship between risk events and risk agents (Pujawan & Geraldin, 2009). Questionnaires were administered to two expert responders. The evaluations from the expert respondents were utilized to compute the

Aggregate Risk Potential (ARP), which then informs the prioritization of risk agents for the development of mitigation strategies. The ranking of risk factors adheres to the Pareto principle. The formula for computing ARP is as follows:

$$ARPj = Oj \sum Si \times Rij \quad (1)$$

Explanation:

ARPj : The average risk potential of risk agent j=1,2,3,...,n
Oj : The occurrence level of risk agent j=1,2,3,..,n
Si : The severity level of risk i=1,2,3,...,n
Rij : The correlation level between risk "I" and risk agent "j"
k : Respondent k=1,2,3,...,n

Phase 2 House of Risk (HOR)

During HOR phase 2, mitigation plans will be formulated to diminish risks, which XYZ MSMEs will execute. The overall effectiveness (Tek) of each approach must be computed using equation (2) to elucidate the efficacy of the mitigation solutions in mitigating risk agents.

$$TEk = Oj \sum Si \times Rij \quad (2)$$

Explanation:

Tek : Total effectiveness
ARPJ : The average risk potential of risk agent j=1,2,3,...,n
Ejk : The level of correlation between risk agent "j" and mitigation strategy "k", where, jk=1,2,3,....,n
K : Respondent k=1,2,3,...,n

III. Result and Discussion

Phase 1 House of Risk (HOR)

The HOR phase 1 seeks to identify risks crucial in establishing the prioritization of risk agents for implementing risk mitigation strategies. The procedures in HOR phase 1 involve identifying hazards and performing risk assessments that analyze severity, occurrence, and the correlation among risk agents, culminating in determining the aggregate risk potential (ARP) value. The ARP calculation seeks to ascertain the precedence of risk agents for implementing risk mitigation strategies.

1. Risk Event and Risk Agent

   The identification of risk events and agents was derived from expert responders, specifically the production manager and the owner of the MSMEs. The identification results indicated 27 risk events and 30 risk agents that may arise at each phase of the wedang uwuh production process. Table 1 provides comprehensive details.

Table 1. Risk Event and Risk Agent

Phase	Risk Event	Code	Risk Agent	Code
Plan	Erroneous market demand forecasts	E1	Unanticipated fluctuations in demand patterns	A1
	Challenges in fulfilling rising client demand	E2	There are religious holidays or seasonal festivities.	A2
	Deficiency of raw material inventory	E3	Suppliers are unable to satisfy buyer demand	A3
	Unexpected equipment failures	E4	Lack of a consistent maintenance schedule for machinery	A4
	Escalated emergency repair expenses	E5		
	Manufacturing inactivity	E6		
Source	Inability to choose suppliers	E7	Supplier constraints	A5
	Suppliers incapable of adjusting to fluctuations in demand	E8	The supplier's volume of raw materials is insufficient to satisfy client demands.	A6

Phase	Risk Event	Code	Risk Agent	Code
	Inconsistent quality of source materials	E9	Variations in meteorological conditions or seasonal influences impact agricultural productivity	A7
Make	Employees experiencing slippage	E10	Slippery floors or surfaces	A8
	Workers sustaining injuries or lacerations from knives	E11	Employees are either rushed or inattentive to their responsibilities	A9
	Reduced spice quality resulting from inadequate drying	E12	Inefficient drying procedure	A10
			Erratic meteorological conditions	A11
	Absence of lime leaf fragrance	E13	Irregular distribution of spices in the oven	A12
	Spice degradation resulting from inconsistent oven temperature	E14	Malfunction or impairment of the oven apparatus	A13
	Excessive machine noise results in auditory health complications for employees.	E15	Utilization of machinery devoid of sound-dampening mechanisms	A14
			Suboptimal operational conditions of machinery	A15
	Production process delay resulting from extended squeezing duration	E16	Unskilled labourers	A16
	Significant accumulation of ginger clusters	E17	Inaccurate stirring velocity or method	A17
	Employees endure burns	E18	Elevated heat and insufficient personal protective equipment	A18
	Lumbar discomfort or musculoskeletal ailments of the back	E19	Non-ergonomic seating position	A19
	The grinding machine encounters obstructions or failures.	E20	The existence of substantial ginger clumps as residue on the grinding apparatus	A20
	Insecure plastic clamps result in leaks in the crystal ginger.	E21	Aggregation of powder or particles in the clip region	A21
	Discrepancies in spice mixture addition	E22	There are no protocols in the packaging procedure	A22
	Breaches in the packaging	E23	Malfunctioning or defective pressing tools	A23
			Negligent packaging procedure	A24
Delivery	Postponement in client delivery	E24	Constrained transportation fleet, complications with delivery routes, and traffic circumstances	A25
	Decline in Customer Satisfaction	E25	Products damaged during transit, delays in packaging or handling prior to shipment	A26

Phase	Risk Event	Code	Risk Agent	Code
			Products coming later than scheduled, complications on the logistics front	A27
Return	Returned merchandise from clients is approaching its expiration date	E26	Miscommunication between the seller and the buyer	A28
			There is no specific agreement concerning product return procedures	A29
	The raw materials fail to conform to the buyer's criteria.	E27	Supplier inaccuracies	A30

2. Severity Assessment

   The severity assessment is conducted to determine the degree of severity or impact of a risk occurrence. The severity evaluation is crucial in determining the ARP score, as it directs attention to risks with the most significant consequences. The effect of an event is evaluated on a scale from 1 to 10. A score of 1 indicates minimal relevance, whilst a score of 10 denotes maximal significance. The evaluation is performed with a questionnaire administered to expert responders. The evaluation outcomes are presented in Table 2.
3. The Assessment of The Correlation Level between Risk Event and Risk Agent

   The subsequent step evaluates the relationship between the risk event and the risk agent. A correlation exists between a risk occurrence and the emergence of a risk agent. The correlation evaluation employs a scale of 0 (no correlation), 1 (low correlation), 3 (medium correlation), and 9 (significant correlation). The findings of the correlation examination are presented in Table 2.
4. Calculation of ARP Value

   The ARP value quantifies the possible risk posed by the risk agent concerning numerous risk occurrences in the manufacture of wedang uwuh. ARP identifies and prioritises risk agents according to their impact on overall risk. The outcomes of the ARP calculation can concentrate on controlling risk agents with the highest scores, maximizing the effectiveness of risk reduction efforts. Table 2 presents a comprehensive example of ARP computation:

   ARP1 = O1((S1 x R11) + (S2 x R21) + (S8 x R81) + (S24 x R241)
   = 6 ((9 x 8) + (9 x 6) + (3 x 6) + (3 x 9)
   = 972

Table 2. House of Risk Phase 1

Risk Event		Risk Agent																													Severity Of Risk
		A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18	A19	A20	A21	A22	A23	A24	A25	A26	A27	A28	A29	A30	
Plan	E1	9	1																												9
	E2	9	9			3						1																			6
	E3			9		3	9	3			3																			1	4
	E4				3											3					3										6
	E5				9									1		3								3								4
	E6			1	3		3							3										1							6
Source	E7					3																									6
	E8	3	3			9																									6
	E9							9																							7
Make	E10								3	1																					3
	E11									9							3														5
	E12											3																			6
	E13												1	3		1															3
	E14													9		3															7
	E15														3	3															5
	E16															1	3														4
	E17									3							3	9													7
	E18																		9												6
	E19																1			3											4
	E20															3					9										6
	E21									3							1					9	3									4
	E22									3							3						9		1							6
	E23									1						3	1							3	9							5
Delivery	E24	3					3																				3		3			9
	E25																											3	9			4
Return	E26																													3	9	7
	E27							1																								5
Occ Of Agent		6	7	7	7	7	6	6	5	5	6	6	3	3	6	5	3	9	7	4	7	5	6	6	3	4	5	3	4	4	5	
ARP		972	630	260.75	458.25	643.5	477	453	45	102.5	66	132	9	156	24.25	412.5	183.75	497.25	321.75	42	438.75	180	338.25	170.5	138	94.5	54	189	84	252	245	
Rank		1	3	13	7	2	6	8	28	4	26	22	30	20	25	10	17	5	12	29	9	18	11	19	21	23	27	16	24	14	15	

Source: (Primary Data, 2024)

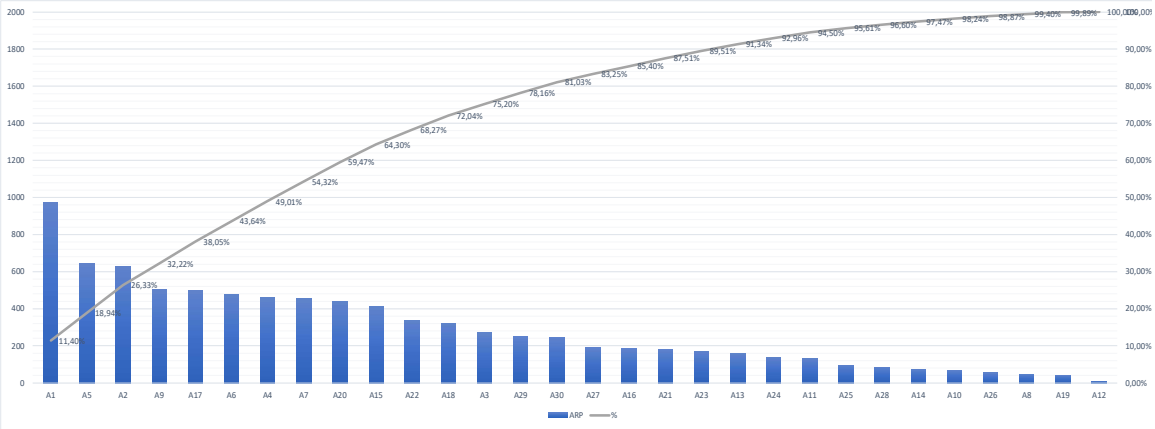
Description:

En = Risk Event
An = Risk Agent
ARP = Value of ARP

The empty column shows a value of 0, indicating no correlation

5. Risk Evaluation

   Risk assessment is performed to establish the precedence of risk management according to its possible effect on the wedang uwuh production process. This assessment seeks to identify risk agents with the most significant risk contribution for prioritization in the mitigation approach. The Pareto diagram (figure 1) assists in identifying the risk factors that contribute most significantly to the overall potential risk, adhering to the 80/20 principle, which posits that 80% of the effects are typically attributable to 20% of the causes. The outcomes of the ARP value computation will be utilized to organize and represent data in a Pareto diagram.



Source: (Primary Data, 2024)

Figure 1. Pareto Diagram

Figure 1 illustrates the outcome of a Pareto analysis conducted on 30 risk agents, prioritized according to their aggregate risk potential (ARP) value, following the 80/20 principle. Among the 30 risk agents, 15 represent 80% of the risk, with a significant portion concentrated in a few primary agents: A1, A5, and A2. The grey curve illustrates the cumulative proportion of ARP value, positioning it as the primary emphasis in risk mitigation strategies. This technique streamlines priorities by reducing risks through minimal contributions (20%), enhancing mitigation efforts' efficacy and efficiency.

House of Risk (HOR) Phase 2

HOR Phase 2 involves the formulation of mitigating solutions. Mitigation strategies arise from the correlation results between mitigation techniques and risk agents. The cumulative effectiveness value (Tek), difficulty level (Dk), and the effectiveness-to-difficulty ratio are computed at this juncture—estimated Time of Departure (ETD).

1. Mitigation Risk Strategy

   The risk mitigation approach is employed to tackle the three risks with the highest ARP or ranking values. Table 3 delineates the mitigation actions that XYZ MSMEs can implement to address the identified risk agents. The three foremost risk agents and their corresponding mitigation techniques are presented here.

a. Erratic Fluctuations in Demand Patterns

   Unpredictable fluctuations in demand, including abrupt surges, are frequently recognized as significant risk factors (Aini et al., 2019; Telaumbanua & Haviana, 2023). MSMEs XYZ needs to systematically record customer demand data, impairing its capacity to forecast market demand and resulting in an unpredictable wedang uwuh production process. Research indicates that fluctuations in market demand might interrupt the supply chain and jeopardize the operational continuity of small enterprises (Shen & Li, 2016). Mitigation methods are required to avert similar incidents in the future. Implementable mitigation measures encompass maintaining organized sales records (PA1) and forecasting demand to comprehend purchasing trends. This is indicated by studies about risk

management in MSMEs within the food and beverage sector (Kacicka, 2023).

b. Constraints of Suppliers

Frequently recognized risk factors encompass raw material shortages, quality concerns, and demand variability (Aini et al., 2019). Integrating mitigation techniques, including multi-sourcing, backup inventory, and alternate transportation, can bolster supply chain resilience and diminish reliance on secondary providers (Suryadi & Rau, 2023). Another technique involves establishing strategic alliances with suppliers, enhancing the performance and competitiveness of small and medium enterprises (MSMEs). Establishing proactive supplier relationships can improve flexibility and strategic performance for small enterprises (Sen et al., 2023). XYZ MSMEs are encountering constraints from suppliers in sourcing raw materials for the production of wedang uwuh. Supplier constraints may result in supply interruptions, either delaying or completely halting the production process. Risk mitigation measures that might be employed encompass empowering local suppliers (PA8) and forming partnerships with farmers or large-scale suppliers (PA9).

c. There exist religious holidays or seasonal events

Seasonal events and religious holidays influence demand trends and production requirements. The changes in demand are a problem for organizations, particularly in managing production capacity and inventories (Bhat & Krishnamurthy, 2016). Organizations may employ several measures to mitigate the risks linked to demand variability, such as demand planning and forecasting methodologies, managing client influx during peak times, and stimulating demand during off-peak intervals (Rajani et al., 2022). Religious holidays or seasonal events result in an abrupt surge in demand, elevating production requirements. The labour restriction might extend the manufacturing timeline, complicating the fulfilment of client demand. Strategies for risk reduction include maintaining product inventory in anticipation of significant holidays or events based on demand forecasts (PA13), establishing a pre-order system for clients during specified periods (PA14), and allocating temporary additional labour (PA15).

Table 3. Risk Agent and Mitigation Strategy

Risk Agent Code	Risk Agent	ARP Value	Strategy Code	Mitigation Strategy
A1	Unanticipated fluctuations in demand trends	972	PA1	Implement systematic sales documentation
			PA2	Anticipate demand to comprehend consumer purchasing habits
A5	Constraints of suppliers	643,5	PA3	Enhance the capabilities of local suppliers
			PA4	Forge partnerships with agricultural producers or major suppliers
A2	There are religious holidays or seasonal festivities	630	PA5	Supply goods inventory before significant holidays or particular events according to demand forecasts
			PA6	Establish a pre-order mechanism for customers during specific intervals
			PA7	Supply temporary supplementary workforce

Risk Agent Code	Risk Agent	ARP Value	Strategy Code	Mitigation Strategy
A9	Employees are either rushed or need more concentration on their tasks	502,5	PA8	Establish a consistent break schedule
			PA9	Supply cut-resistant gloves to employees
A17	The mixing speed or technique needs to be corrected	497,25	PA10	Instruct employees on appropriate stirring methodologies
			PA11	Develop a standard operating procedure (SOP) for the stirring process and ensure all personnel adhere to it
			PA12	Supply stirring implements to attain more uniform outcomes
A6	The supplier's volume of raw materials needs to be increased to satisfy client demands	477	PA13	B Establish contracts with suppliers that permit flexibility in delivery quantities and schedules
A4	There has yet to be an established schedule for equipment maintenance	458,25	PA14	Perform routine inspections, maintenance, and sanitation of equipment
			PA15	Develop a concise checklist to guarantee the timely execution of maintenance tasks
A7	Variations in meteorological conditions or seasons influence agricultural productivity	453	PA16	Exploring alternate raw materials from diverse climatic locations
			PA17	Ensuring an ample inventory of raw materials during the harvest season to guarantee supply
A20	The existence of substantial aggregates of ginger residue in the grinding apparatus	438,75	PA14	Performing routine inspections, maintenance, and sanitation of equipment
A15	The machine's inadequate state	412,5	PA14	Performing routine inspections, maintenance, and sanitation of equipment
			PA18	Supplying employees with auditory protection (earplugs or earmuffs) to mitigate noise exposure
A22	The lack of protocols in the spice-filling process	338,25	PA19	Formulating and executing specialized Standard Operating Procedures in the packaging process
A18	Elevated temperatures and the absence of personal protective equipment	321,75	PA20	Supplying personal protective equipment (gloves, masks, and aprons) to employees
A3	The supplier is unable to fulfil the buyer's demand.	269,75	PA21	Diversifying the supplier network to procure raw materials externally from the primary provider

Risk Agent Code	Risk Agent	ARP Value	Strategy Code	Mitigation Strategy
A29	The lack of a legal agreement about product return conditions	252	PA22	Establishing formal contracts with business-to-business (B2B) clients that encompass the return of non-standard or defective products and equitable conditions for both sides.
A30	Supplier inaccuracies	245	PA23	Delivering explicit raw material specification directives to suppliers
			PA24	Enhancing communication with suppliers to avert miscommunication

2. Relationship between Mitigation Risk Strategy and Risk Agent

The computation of the correlation coefficient between the risk mitigation method and the risk agent is to ascertain the degree of association or impact of risk mitigation on the specified risk agent. The evaluation is performed via a questionnaire. The correlation scale includes 0 (no connection), 1 (poor correlation), 3 (moderate correlation), and 9 (high correlation). The comprehensive correlation computations are presented in Table 4.

3. Computation of TEk and the Outcome of Dk

The computation of the Tek value is performed to evaluate the efficacy of the risk mitigation methods formulated to tackle emerging risk agents. TEk is determined using equation (2). The outcomes of the Tek and Dk computations are presented in Table 3. Illustrative computation of TEk value as follows:

$$TE1 = \sum (972 \times 9)$$
$$= 8748$$

4. Computation of ETDk Ratio

The ETDk value is calculated to ascertain the priority ranking of current mitigation methods. The most excellent ETDk value indicates the most effective technique for mitigating existing risk agents. The comprehensive computation of the ETDk value is presented in Table 4, accompanied by an example of the ETDk value calculation as follows:

$$ETDk = 8748 / 4$$
$$= 2187$$

5. Table of HOR Phase 2

Table 4 presents the sequence of risk mitigation methods applicable to MSMEs XYZ for optimizing the production process of wedang uwuh during HOR phase 2. The priority order values are derived from the calculation of ETD values, arranged from most significant to lowest.

Table 4 presents 24 risk mitigations

Table 4. House of Risk Phase 2

Risk Agent	Mitigation Strategy																								ARP
	PA1	PA2	PA3	PA4	PA5	PA6	PA7	PA8	PA9	PA10	PA11	PA12	PA13	PA14	PA15	PA16	PA17	PA18	PA19	PA20	PA21	PA22	PA23	PA24	
A1	9	3																							972
A5			1	9																					643,5
A2					3	9	3																		630
A9								9	3																502,5
A17										1	9	3													497,25
A6													9												477
A4														9	3										458,25
A7																3	9								453
A20														9											438,75
A15														3				3							412,5
A22																			3						338,25
A18																				9					321,75
A3																					9				269,75
A29																						9			252
A30																							9	3	245
TEk	8748	2916	643,5	5791,5	1890	5670	1890	4522,5	1507,5	497,25	4475,25	1491,75	4293	9310,5	1374,75	1359	4077	1237,5	1014,75	2895,75	2427,75	2268	2205	735	
Dk	4	4	3	3	4	4	3	5	4	3	3	3	3	4	3	4	3	3	4	3	3	3	4	3	
ETDk	2187	729	214,5	1930,5	472,5	1417,5	630	904,5	376,875	165,75	1491,75	497,25	1431	2327,625	458,25	339,75	1359	412,5	253,6875	965,25	809,25	756	551,25	245	
Rank	2	12	23	3	16	6	13	9	19	24	4	15	5	1	17	20	7	18	21	8	10	11	14	22	

Source: (Primary Data, 2024)

prioritized from highest to lowest to address 15 sources of risk. Risk agent. Regularly doing inspections, maintenance, and cleaning of equipment (PA14), Documenting sales systematically (PA1), Forming partnerships with agricultural producers or major suppliers (PA4), Developing Standard Operating Procedures for the stirring process and guaranteeing worker adherence to them (PA11), Establishing contracts with suppliers that permit flexibility in delivery quantities and schedules (PA13), Establishing a pre-order system for customers during specific intervals (PA6), Ensuring an ample inventory of raw materials during the harvest season to guarantee supply (PA17), Supplying personal protective equipment (gloves, masks, and aprons) to employees (PA20), Establishing a consistent break schedule (PA8), Diversifying the supplier network (PA21) to procure raw materials externally from the primary source. Establish formal agreements with business-to-business (B2B) clients that encompass the return of non-standard or damaged goods, along with equitable terms for both parties (PA22), and execute demand forecasting to analyze consumer demand patterns. Providing temporary supplementary labour (PA7), delivering explicit raw material specification recommendations to suppliers (PA23), supplying stirring aids to attain more uniform outcomes (PA12), and ensuring product inventory in advance of holidays or specific events based on demand forecasts (PA5). Formulating a straightforward checklist to guarantee timely maintenance (PA15), Supplying employees with auditory protection (earplugs or earmuffs) to mitigate noise exposure (PA18), Distributing cut-resistant gloves to personnel (PA9), Exploring alternative raw materials from diverse climatic regions (PA16), Designing and executing specific Standard Operating Procedures (SOPs) in the packaging process (PA19), Enhancing communication with suppliers to avert misunderstandings (PA24), Supporting local suppliers (PA3), Offering training to workers on appropriate stirring techniques (PA10).

IV. CONCLUSION

MSMEs XYZ experienced 27 risk occurrences and had 30 risk agents. A total of 15 risk agents were chosen according to the highest Aggregate Risk Potential (ARP) value, resulting in a cumulative percentage of 81.03%. These 15 risk agents encompass all risk agents capable of risk mitigation. This analysis emphasizes 24 mitigation options, with PA14 receiving the highest importance. Inspections, maintenances, and tool cleanings periodically. This method is crucial for averting abrupt damage, enhancing manufacturing efficiency, and minimizing downtime. Regular maintenance has been demonstrated to enhance operational efficiency and mitigate supply chain interruptions (Kumar, 2022).

The subsequent research recommendation is the advancement of technology-driven mitigation, including IoT integration for real-time machine surveillance, which can offer early alerts of potential damage and optimize productivity (Govindasamy et al., 2024). Moreover, supplier diversification is crucial to diminish reliance on a singular provider and alleviate supply chain disruptions (Maemunah, 2024);(Karanam et al., 2024). The community-based strategy is as crucial for establishing a dependable supply while fostering the community's economic empowerment (Halili & Fernando, 2019).

This study highlights the necessity of risk mitigation to minimize the likelihood of substantial losses in the supply chain of XYZ MSMEs. Mitigation priorities should be assigned to risk agents exhibiting the most excellent ARP values. Implementing a sustainable risk management system grounded in the house of risk (HOR) can guarantee the systematic identification, prioritization, and mitigation of risks, bolster operational efficiency, and strengthen the supply chain's resilience against future disruptions.

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