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Operational Risk Analysis and Prioritization of Mitigation Strategies in the Production Process of Processed Sweet Potato Products at Ummah Cookies

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***Abstract*—The development of the local food industry in Indonesia faces challenges due to the increasing dominance of modern and imported food products, which have caused local food-based processed products to be increasingly marginalized. Ummah Cookies, as a local food processing MSME based on sweet potatoes and cassava, still faces various operational risks that have the potential to affect product quality and the stability of the production process. This study aims to analyze operational risks and determine risk mitigation strategies in the production process of sweet potato processed products at Ummah Cookies. The method used in this study is a combination of Failure Mode and Effects Analysis (FMEA) and Analytical Hierarchy Process (AHP). The FMEA method is used to identify and prioritize risks based on Severity, Occurrence, and Detection values through the calculation of the Risk Priority Number (RPN), while the AHP method is used to determine the priority of risk mitigation strategies. The results of the study showed that the highest risk in sweet potato brownie products was at the production stage in the form of the emergence of a strong sweet potato aroma with an RPN value of 330. Meanwhile, in sweet potato porridge products, the highest risk was at the post-production stage in the form of products that spoil quickly during storage, with an RPN value of 342. The results of the AHP analysis showed that the priority of risk mitigation in sweet potato brownies lies in the production aspect, with an eigenvector value of 0.61, while in sweet potato porridge, it lies in the post-production aspect with an eigenvector value of 0.49. Recommended risk mitigation strategies include controlling the quality of raw materials, controlling the temperature and cooking process, implementing production SOPs, and optimizing product storage and packaging systems. The implementation of these strategies is expected to be able to maintain product quality stability, increase production process efficiency, and minimize potential losses in local food MSMEs.**

Keywords : **AHP, FMEA, Local Food, Risk Mitigation**.

I. Introduction

The development of the local food industry in Indonesia currently faces increasingly complex challenges due to the increasing dominance of imported snack products and modern foods that prioritize practicality over nutritional value. This phenomenon has increasingly marginalized traditional snacks made from local foods amidst changing consumption patterns of modern society. In fact, Indonesia has abundant local agricultural resources, such as sweet potatoes and cassava, which are rich in carbohydrates, fiber, and vitamins, and have great potential to be developed into processed food products with high economic value [Estiasih et al, 2018]. Furthermore, the use of local food ingredients is considered capable of supporting national food security and reducing dependence on imported food products [Widowati, 2019]. On the other hand, increasing public awareness of the importance of consuming healthy and natural foods opens up opportunities for micro, small, and medium enterprises (MSMEs) to present innovative, healthy, and competitive local food products in the market [Widianarko, 2020]. The development of sweet potato and cassava-based processed products is also a strategy to increase the added value of local agricultural commodities while supporting the preservation of traditional Indonesian culinary arts [Nurhayati and Prasetyo, 2021].

One micro-enterprise specializing in local food processing is Ummah Cookies, located in

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Glonggongan Hamlet, Sumbertebu Village, Bangsal District, Mojokerto Regency. Founded in 2020, the business focuses on producing healthy snacks made from local resources, such as sweet potatoes, cassava, palm sugar, and coconut, as part of an effort to develop traditional food products with nutritional and economic value.

In the early stages of its production, Ummah Cookies produced various types of traditional snacks made from sweet potato and cassava, such as klepon, gethuk, kue talam, and lemet, which were marketed through traditional markets in the Mojokerto region, namely Sawahan Bangsal Market and Mojosari Market. These products represent a form of utilizing local foods that have cultural and economic value as part of the preservation of traditional regional cuisine [Widowati, 2018]. As consumer demand for more innovative and practical local food products increases, Ummah Cookies has diversified its products by developing various modern processed products made from sweet potato and cassava, such as sweet potato-filled soes, sweet potato croquettes, sweet potato balls, sweet potato brownies, and sweet potato bubu. Product diversification is an important strategy in increasing the competitiveness of local food businesses by creating product variations that suit the needs and preferences of the modern market [Winarno, 2020]. The development of this business is also demonstrated by the increasing operational capacity of the company, which is currently supported by 10 employees and has 5 sales outlets as a means of distributing products to consumers. This situation indicates that the development of local food-based products has significant potential to increase the growth of micro-enterprises while supporting the economic empowerment of the surrounding community [Nurhayati and Prasetyo, 2021]. Although Ummah Cookies has good economic potential and has experienced increased production, its production process still faces various operational risks, such as limited raw materials, inconsistent quality of sweet potatoes and cassava, product damage, and distribution delays. Dependence on local raw materials also causes the production process to be affected by supply conditions and seasonal factors [Pujawan and Mahendrawathi, 2017]. Poorly managed operational risks can reduce product quality, production efficiency, and business sustainability. Therefore, operational risk analysis is necessary to determine appropriate mitigation strategies to maintain production process stability [Pujawan, 2019]. In the local food industry, operational risk management is a crucial aspect for maintaining production process stability and increasing business competitiveness. Operational risk analysis is needed to identify potential failures at each stage of production so that business actors can determine risk management priorities and appropriate mitigation strategies. The implementation of planned risk mitigation can minimize losses, maintain product quality, increase production efficiency, and support the sustainability of local food businesses [Yuniarti, 2021].

The purpose of this study is to analyze operational risks in the local food industry to maintain the stability of the production process and increase the competitiveness of Ummah Cookies' business. Operational risks that are not managed properly can lead to decreased product quality, production delays, and even business losses. Therefore, a risk analysis is needed to identify potential failures at each stage of production and determine appropriate mitigation strategies [Yuniarti, 2021]. In this study, the method used is Failure Mode and Effects Analysis (FMEA), used to identify and analyze risk levels based on Severity, Occurrence, and Detection values, and the Analytical Hierarchy Process (AHP) method is used to systematically determine the priority of risk mitigation strategies [Stamatis, 2003]. Research on the yogurt production process shows that the FMEA method is able to identify dominant risks in yogurt production by showing the highest risks including bacterial contamination in fresh milk, decreased quality of starter bacteria during the production process, and the presence of competitors of similar products while the results of AHP calculations show three priority strategies to minimize risks, namely improving the quality of raw materials through training, strengthening business partnerships, and improving maintenance of production machines and equipment [Prasetiyo et al, 2017]. Another study on the Elfath Macaroni and Cheese food processing MSME showed that the integration of Fuzzy FMEA and Fuzzy AHP successfully identified 14 production risks originating from raw materials, processing, and packaging, with priority mitigation results in the form of partnerships with suppliers and maintenance of

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production machines as the main strategy [Riana and Ghofari, 2024]. In addition, research on the shallot supply chain proved that the combination of FMEA and AHP methods is effective in determining risk priorities and mitigation strategies to maintain the stability of supply and quality of food products [Winanto and Santoso, 2017]. The novelty of this research lies in the application of the integration of the Failure Mode and Effects Analysis (FMEA) and Analytical Hierarchy Process (AHP) methods in risk analysis and determination of mitigation strategies in the production process of local food-based processed products, especially sweet potatoes at the Ummah Cookies MSME. The integration of these two methods is not only used to identify the level of risk through the Risk Priority Number (RPN), but also to produce priority mitigation decisions based on multi-criteria more objectively and systematically. Thus, this research contributes to the development of an integrated risk management model that is applicable for local food MSMEs in order to improve quality consistency, production process efficiency, and the competitiveness of local commodity-based products in a sustainable manner.

II. Research method

This study uses a risk management approach that includes identification, analysis, evaluation, and determination of risk mitigation strategies to analyze operational risks in the production process of processed sweet potato products at Ummah Cookies. Risk management is used to anticipate potential disruptions during the production process so that the company can minimize the impact of possible losses. In the production process of processed sweet potato products, risks can arise at the stages of raw material procurement, processing, packaging, and product storage. The method used in this study is a combination of Failure Mode and Effects Analysis (FMEA) and Analytical Hierarchy Process (AHP). The FMEA method is used to identify potential failure modes that can occur at each stage of the production process, along with their resulting impacts. FMEA is a systematic method that aims to analyze the possibility of failure, the causes of failure, and the consequences that can arise so that companies can determine preventive measures more effectively. FMEA is effectively used to identify sources of process failures preventively so as to improve the quality and reliability of production systems [Stamatis, 2003]. In addition, FMEA is one of the most widely used methods in industrial risk analysis because it is able to prioritize risks based on their critical level [Liu, 2013]. Another study, the application of FMEA in the manufacturing sector, can help companies in determining risk control strategies in a more structured and systematic manner [Kutlu, 2012]. Through this method, each risk is analyzed based on three main parameters, namely the severity of the impact (severity), frequency of occurrence (occurrence), and detection ability (detection). The values of these three parameters are then used to calculate the Risk Priority Number (RPN) with the formula.

$$\text{RPN} = \text{Severity} \times \text{Occurrence} \times \text{Detection} \quad (1)$$

The RPN value is used to determine the priority level of operational risks that require immediate corrective action in the production process of sweet potato food products at Ummah Cookies. Furthermore, the Analytical Hierarchy Process (AHP) method is used to determine the priority of risk mitigation strategies based on the results of risk identification using FMEA. The AHP method was chosen because it is able to solve complex problems through the preparation of a decision hierarchy and pairwise comparisons between criteria and alternative mitigation strategies. The assessment is carried out through pairwise comparisons between mitigation criteria such as control effectiveness, implementation costs, ease of application, and impact on the smoothness.

Of the quality of the production process.
of the production process. The results of the AHP calculation produce priority weights that can be used as a basis for decision-making in determining the most effective risk mitigation strategy [Triantaphyllou and Mann, 1995]. AHP is able to increase the accuracy of determining decision priorities because it consistently considers the level of importance of each criterion [Chopra and Meindl, 2016]. In addition, AHP is effective for use in decision support systems because it has the ability to integrate subjective assessments and quantitative data into a single decision model. Other research also explains that integrating FMEA and AHP methods can help companies determine risk mitigation priorities more objectively and measurably, thereby supporting

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improvements in the quality of production processes [Vaidya, 2016].

III. Result and discussion

3.1 Risk Identification in the Sweet Potato Processed Product Production Process at Ummah Cookies

The identification process was conducted through direct observation of production activities, interviews with business owners and workers, and analysis of the production process flow of processed sweet potato products. The identification results revealed several potential risks, such as non-conformity in the quality of sweet potato raw materials, errors in the dough mixing process, damage to production equipment, inconsistent baking temperatures, and errors in the product packaging process. These risks have the potential to cause a decrease in product quality, production delays, increased operational costs, and losses for the company. During the data collection process, operational risks in the production of processed sweet potato products at Ummah Cookies were grouped into three main stages: pre-production risks, production process risks, and post-production risks. This grouping was carried out to facilitate the identification of risk sources in each production flow in a systematic and measurable manner.

3.1.1 Operational Risks in Sweet Potato Brownie Production

Table 1. The results of the operational risk identification in the sweet potato brownie production process at Ummah Cookies are presented

Risk Factor	Risk
Pre-Production Risks	Delay in sweet potato supply
	Sweet potato quality does not meet standards.
	Sweet potatoes experience spoilage
	Limited availability of raw materials
	Fluctuation in raw material prices
	Wheat flour becomes clumpy or has a musty odor.
	Eggs are not fresh
Production Risks	Errors in brownie batter formulation
	The batter is not mixed evenly.
	Workers' hands were injured by production equipment.
	Damage to mixers or production ovens
	Unstable baking temperature
	Brownies become overbaked or burnt.
	Brownie texture is too soft.
	The sweet potato aroma is too strong.
	The product does not rise properly.
Post-Production Risks	Product packaging is damaged.
	Product labeling errors
	Quality deterioration during storage
	Delay in product distribution
	Product damage during delivery
	Consumer complaints regarding product quality

3.1.1 Operational Risks in Sweet Potato Porridge Production

The results of the operational risk identification in the sweet potato porridge production process at Ummah Cookies are presented in Table 2.

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Table 2. Risk Identification in Sweet Potato Porridge at Ummah Cookies

Risk Factor	Risk
Pre-Production Risks	Delay in sweet potato supply
	Sweet potato quality does not meet standards.
	Sweet potatoes undergo spoilage.
	Limited availability of raw materials
	Fluctuation in raw material prices
	Inadequate raw material storage
Production Risks	Sweet potatoes are not fully cooked during boiling.
	Workers' hands are exposed to hot steam during processing.
	The porridge texture is too watery.
	The porridge texture is too thick.
	Milk or coconut milk curdles during cooking.
	Sugar does not dissolve completely.
	Porridge forms lumps during the stirring process.
	Contamination by foreign materials during production
	Production equipment malfunction
	Porridge gets burnt due to unstable cooking temperature.
Post-Production Risks	Packaging leaks or becomes damaged.
	The product spoils quickly during storage.
	Product labeling errors
	Delay in product distribution
	Product damage during the delivery process

3.2 Risk Level Measurement in Sweet Potato Processed Product Production Activities at Ummah Cookies

3.2.1 Risk Priority Number (RPN) Calculation Results for Sweet Potato Brownies Products

Based on the Risk Priority Number (RPN) calculation in the sweet potato porridge production process at Ummah Cookies, the highest priority risk in the pre-production stage is the non-conformity of sweet potato quality with production standards, with an RPN value of 315. This risk is caused by the presence of boleng sweet potatoes, characterized by physical damage, increased water content, soft texture, and indications of decay due to storage of raw materials beyond the standard shelf life. Prolonged storage of sweet potatoes can increase microbial activity and accelerate the post-harvest senescence process, causing softening of the texture and a decrease in the sensory quality of the product [Song et al, 2021]. In the production stage, the risk with the highest RPN value, 330, is the emergence of a strong sweet potato aroma during processing. This risk is influenced by the quality of raw materials that are starting to experience quality decline, inaccurate control of temperature and cooking time, and an unbalanced product formulation composition, so that the distinctive sweet potato aroma becomes too dominant in the final product. According to several studies, the aroma characteristics of sweet potatoes are influenced by the composition of volatile compounds formed during the heating process, including aldehydes, furans, terpenoids, and compounds resulting from the Maillard reaction. Other studies have shown that formulations with high sweet potato concentrations have the potential to produce an overly dominant aroma profile, thereby reducing the balance of sensory attributes and consumer acceptance of the product [Zhou et al, 2024]. Meanwhile, in the post-production stage, the risk with the highest priority level is a decrease in product quality during the storage process, with a

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Risk Priority Number (RPN) value of 160. This risk is influenced by the water content in sweet potato brownies, suboptimal storage conditions, a packaging system that is not able to maintain optimal product quality stability, and products produced without the use of preservatives. These conditions have the potential to cause changes in the texture, aroma, and taste of the product, thereby reducing the shelf life and quality of sweet potato brownies before distribution to consumers at Ummah Cookies.

The calculation results of the Risk Priority Number (RPN) value can be the basis for Ummah Cookies MSME in developing risk mitigation strategies at each production stage. The integration of FMEA and AHP is carried out sequentially, with the highest RPN at each process stage, and then used as the basis for compiling a decision hierarchy in AHP to evaluate and determine the priority of the most effective mitigation alternatives. Based on the results of the research on brownie products, Ummah Cookies MSME needs to strengthen control at all stages of production. In the pre-production stage, control is carried out by tightening the raw material selection process through visual inspection to ensure compliance with sweet potato quality standards, implementing a first-in-first-out (FIFO) system in inventory management, and limiting the storage time of raw materials to prevent quality degradation. In the production stage, standardization of formulations and the preparation of Standard Operating Procedures (SOPs) related to temperature and cooking time settings are needed to ensure consistent product sensory characteristics between batches. Meanwhile, in the post-production stage, improvement efforts are focused on improving the quality of packaging that has better protection capabilities, controlling storage conditions, and determining shelf life based on product quality testing results.

3.2.2 Risk Priority Number (RPN) Calculation Results for Sweet Potato Porridge

Based on the Risk Priority Number (RPN) calculation for the sweet potato porridge production process at Ummah Cookies, the highest risk occurs in the post-production stage, namely rapid product spoilage during storage, with an RPN of 342. This risk is influenced by the product's relatively short shelf life, suboptimal storage conditions, and potential contamination during storage and distribution. Other research shows that the highest risks in food products generally occur during the storage stage due to short shelf life, environmental conditions, and microbiological contamination [Kumar et al, 2023]. In the pre-production stage, the greatest risk comes from substandard sweet potato quality, with an RPN of 315. This risk is caused by inappropriate levels of ripeness, texture, and condition of raw materials, which can affect the quality of the final product. Meanwhile, in the production stage, the greatest risk is burnt porridge due to unstable cooking temperatures, with an RPN of 105. This risk has the potential to reduce the quality of the product's taste, aroma, and texture, thereby increasing the number of defective products during the production process.

The results of the FMEA risk identification and assessment are then used as the basis for integration with the Analytical Hierarchy Process (AHP) method. The results of this integration have significant operational implications for the Ummah Cookies MSME in controlling the production process. In the pre-production stage, strengthening is carried out through the implementation of stricter raw material selection standards based on visual inspection and quality control during the receiving process to ensure conformity to specifications. In the production stage, stabilization of process parameters is required, especially temperature control and standardization of cooking procedures to minimize process variation and reduce the potential for defective products. Meanwhile, in the post-production stage, optimization of the packaging system, control of storage conditions, and determination of shelf life based on quality testing results are priority aspects in maintaining product quality stability until the distribution stage.

3.3 Determining Priority Risk Mitigation Strategies for Processed Sweet Potato Products at Ummah Cookies

In this study, prioritization of mitigation strategies was conducted using the Analytical Hierarchy Process (AHP) method. Alternative mitigation strategies were developed based on interviews and questionnaires distributed to respondents directly involved in Ummah Cookies' operational activities. Respondents included

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business owners and production workers who understood the production process conditions and potential risks that arise at each stage of product processing. The results of the risk mitigation strategy formulation for sweet potato brownies and sweet potato porridge are presented in Tables 3 and 4.

Table 3. Alternative risk mitigation strategies for Sweet Potato Brownies

Risk Variable	Risk	Alternative Risk Mitigation Strategies
Pre-Production Risks	Sweet potato quality does not meet standards	1. Establish sweet potato specification standards, including size, maturity level, flesh color, moisture content, and level of damage, before raw materials are accepted.
	Sweet potatoes undergo spoilage	2. Implement a raw material storage system with temperature and humidity control, as well as the FIFO (First In First Out) method.
	Delay in sweet potato supply	3. Control the steaming process and batter formulation by regulating time, temperature, and adding aroma-balancing ingredients such as vanilla or chocolate.
	Limited availability of raw materials	4. Use standardized formulations and digital weighing to ensure ingredient composition complies with production standards.
	Fluctuation in raw material prices	5. Conduct routine calibration and maintenance of mixers and ovens to maintain the stability of mixing and baking processes.
	Wheat flour becomes clumpy or musty	6. Use airtight food-grade packaging and implement temperature and storage-time control for finished products.
	Eggs are not fresh	–
Production Risks	The sweet potato aroma is too strong.	–
	Errors in brownie batter formulation	–
	The batter is not mixed evenly.	–
	The product does not rise properly.	–
	Brownie texture is too soft.	–
	Brownies are overbaked or burnt.	–
	Baking temperature is unstable.	–
	Damage to mixers or production ovens	–
	Workers' hands were injured by production equipment.	–
Post-Production Risks	Quality deterioration during storage	–
	Product damage during delivery	–
	Consumer complaints regarding product quality	–
	Product labeling errors	–
	Delays in product distribution	–
	Product packaging damage	–

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Table 4. Alternative risk mitigation strategies for Sweet Potato Porridge

Risk Variable	**Risk**	**Alternative Risk Mitigation Strategies**
Pre-Production Risks	Sweet potato quality does not meet standards	1. Conduct raw material inspections based on physical parameters, including tuber size, flesh color, level of damage, and maturity level, to ensure uniformity of raw material characteristics.
	Sweet potatoes undergo spoilage	2. Store sweet potatoes in a storage room at 15–20°C with controlled humidity to slow down the activity of spoilage-causing microorganisms.
	Limited raw material availability	3. Control the cooking temperature within the range of 80–90°C, accompanied by continuous stirring to maintain even heat distribution and prevent excessive gelatinization at the bottom of the container.
	Fluctuating raw material prices	4. Boil the sweet potatoes until optimal gelatinization occurs, then blend evenly and cook at 80–90°C with continuous stirring to prevent sedimentation and scorching at the bottom of the container.
	Delays in sweet potato supply	5. Implement the use of personal protective equipment such as heat-resistant gloves, aprons, and long-handled stirring tools during the boiling and cooking processes.
	Inadequate raw material storage	6. Package the product at temperatures below 40°C using airtight food-grade containers and store the product at refrigeration temperatures of 4–10°C to inhibit microbial growth.
Production Risks	Porridge burns due to unstable cooking temperature.	
	Sweet potatoes are not fully cooked during boiling.	
	The porridge texture is too thin.	
	The porridge texture is too thick.	
	Milk or coconut milk curdles during cooking.	
	Sugar does not dissolve completely.	
	Porridge forms lumps during stirring.	
	Foreign material contamination during production	
	Workers' hands are exposed to hot steam during processing.	
	Production equipment damage	
Post-Production Risks	The product spoils quickly during storage.	
	Packaging leaks or is damaged.	
	Product damage during transportation	
	Delays in product distribution	
	Product labeling errors	

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3.4. Hierarchical Model of Risk Mitigation Strategies in Sweet Potato Brownie Production

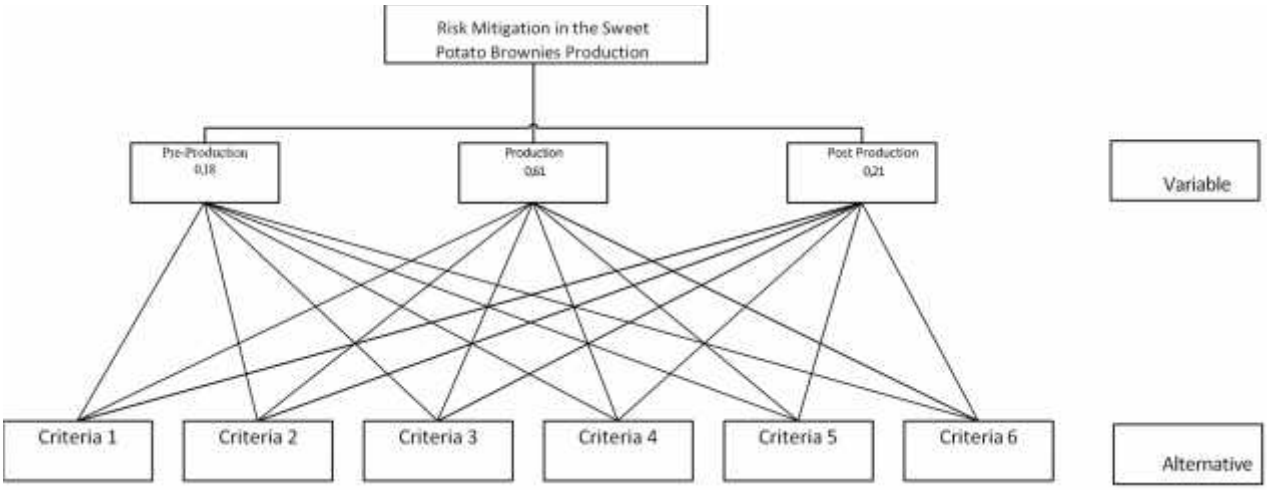

Figure 1. Hierarchical Model of Risk Mitigation Strategies in Sweet Potato Brownie Production

The eigenvector value for the production aspect is 0.61, indicating that the production stage is the top priority in developing a risk mitigation strategy for sweet potato brownies. Meanwhile, the post-production and pre-production aspects have weights of 0.21 and 0.18, respectively, indicating a relatively lower level of risk influence compared to the production stage.

3.5. Hierarchical Model of Risk Mitigation Strategies in Cassava Porridge Production

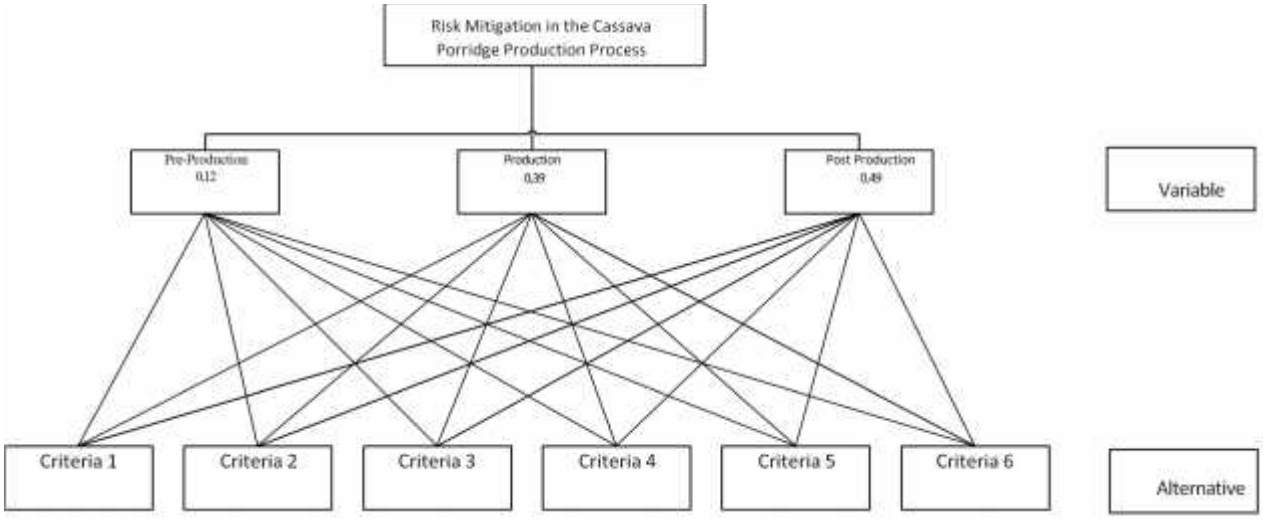

Figure 2. Hierarchical Model of Risk Mitigation Strategies in Cassava Porridge Production

The eigenvector value of 0.49 for the post-production aspect indicates that this stage carries the highest risk level in the sweet potato porridge production process. Meanwhile, the production and pre-production aspects have lower priority levels, with values of 0.39 and 0.12, respectively.

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4. CONCLUSION

The production process at Ummah Cookies still faces various risks in the pre-production, production, and post-production stages that have the potential to affect product quality and stability. For sweet potato brownies, the highest priority risk is in the production stage, namely the emergence of a strong sweet potato aroma with a Risk Priority Number (RPN) of 330. This risk is influenced by the decline in the quality of raw materials, inaccurate cooking temperature control, and suboptimal product formulation. Meanwhile, for sweet potato porridge products, the highest risk is in the post-production stage in the form of products that spoil quickly during storage, with an RPN of 342, which is influenced by limited product shelf life, suboptimal storage conditions, and potential contamination during distribution. The results of the Analytical Hierarchy Process (AHP) analysis show that the priority for risk mitigation in sweet potato brownies lies in the production aspect, with an eigenvector value of 0.61, while for sweet potato porridge, it lies in the post-production aspect, with an eigenvector value of 0.49. Therefore, implementing risk mitigation strategies through controlling the quality of raw materials, controlling temperature and cooking processes, implementing production SOPs, and optimizing storage and packaging systems are important steps in maintaining product quality stability and minimizing potential damage during the production and distribution process.

REFERENCES

[1] M. Estiasih dan K. Ahmadi, *Teknologi Pengolahan Pangan*. Jakarta, Indonesia: Bumi Aksara, 2018.

[2] S. Widowati, "Pemanfaatan pangan lokal dalam mendukung ketahanan pangan nasional," *Jurnal Pangan*, vol. 21, no. 1, pp. 1–10, 2019.

[3] A. Widianarko, "Tren konsumsi pangan sehat dan peluang pengembangan UMKM pangan lokal di Indonesia," *Jurnal Teknologi dan Industri Pangan*, vol. 31, no. 2, pp. 120–128, 2020.

[4] R. Nurhayati dan D. Prasetyo, "Diversifikasi produk olahan ubi jalar sebagai upaya peningkatan nilai tambah komoditas lokal," *Jurnal Agroindustri Indonesia*, vol. 9, no. 1, pp. 45–53, 2021.

[5] S. Widowati, "Diversifikasi konsumsi pangan berbasis pangan lokal," *Jurnal Pangan*, vol. 20, no. 1, pp. 45–56, 2018.

[6] A. Winarno, "Strategi pengembangan produk pangan lokal dalam meningkatkan daya saing UMKM," *Jurnal Teknologi dan Industri Pangan*, vol. 30, no. 2, pp. 110–118, 2020.

[7] R. Nurhayati dan D. Prasetyo, "Pengembangan usaha pangan lokal berbasis komoditas ubi dan singkong pada UMKM," *Jurnal Agroindustri Indonesia*, vol. 9, no. 1, pp. 40–49, 2021.

[8] A. Pujawan dan E. Mahendrawathi, *Supply Chain Management*, 3rd ed. Yogyakarta, Indonesia: Andi, 2017.

[9] I. N. Pujawan, "Supply chain risk management," *Jurnal Teknik Industri*, vol. 10, no. 1, pp. 1–8, 2019.

[10] R. Y. Yuniarti, "Analisis risiko operasional pada industri pangan UMKM menggunakan metode FMEA," *Jurnal Teknik Industri*, vol. 12, no. 2, pp. 101–110, 2021.

[11] H. A. Stamatis, *Failure Mode and Effect Analysis: FMEA from Theory to Execution*, 2nd ed. Milwaukee, WI, USA: ASQ Quality Press, 2003.

[12] M. D. Prasetiyo, I. Santoso, S. A. Mustaniroh, dan Purwadi, "Penerapan Metode FMEA dan AHP dalam Perumusan Strategi Pengelolaan Risiko Proses Produksi Yoghurt," *Jurnal Teknologi Pertanian*, vol. 18, no. 1, pp. 1–10, 2017.

[13] O. Riana dan A. K. Al Ghofari, "Analisis Risiko Produksi menggunakan Metode Fuzzy Failure Modes and Effects Analysis (FMEA) dan Fuzzy Analytical Hierarchy Process (AHP) (Studi Kasus: UMKM Makaroni Keju Elfath)," *Prosiding Simposium Nasional Rekayasa Aplikasi Perancangan dan Industri*, pp. 120–128, 2024.

[14] E. A. Winanto dan I. Santoso, "Integrasi Metode Fuzzy FMEA dan AHP dalam Analisis dan Mitigasi Risiko Rantai Pasok Bawang Merah," *Jurnal Teknologi & Industri Hasil Pertanian*, vol. 22, no. 1, pp. 21–32, 2017.

p-ISSN 2622-2027
DOI: https://doi.org/10.36456/tibuana.9.02.11518 *e*-ISSN 2622-2035

[15] D. H. Stamatis, *Failure Mode and Effect Analysis: FMEA from Theory to Execution*, 2nd ed. Milwaukee, WI, USA: ASQ Quality Press, 2003.

[16] H.-C. Liu, L. Liu, and N. Liu, "Risk evaluation approaches in failure mode and effects analysis: A literature review," *Expert Systems with Applications*, vol. 40, no. 2, pp. 828–838, 2013.

[17] A. C. Kutlu and M. Ekmekçioğlu, "Fuzzy failure modes and effects analysis by using fuzzy TOPSIS-based fuzzy AHP," *Expert Systems with Applications*, vol. 39, no. 1, pp. 61–67, 2012.

[18] E. Triantaphyllou and S. H. Mann, "Using the analytic hierarchy process for decision making in engineering applications: Some challenges," *International Journal of Industrial Engineering*, vol. 2, no. 1, pp. 35–44, 1995.

[19] V. K. Chopra and R. Meindl, *Supply Chain Management: Strategy, Planning, and Operation*, 6th ed. Boston, MA, USA: Pearson, 2016.

[20] O. S. Vaidya and S. Kumar, "Analytic hierarchy process: An overview of applications," *European Journal of Operational Research*, vol. 169, no. 1, pp. 1–29, 2006.

[21] Song, H. H., Zhou, Z. L., Zhao, D. L., Tang, J., Li, Y. H., Han, Z., Chen, X. Y., Hu, K. D., Yao, G. F., & Zhang, H. (2021). *Storage property is positively correlated with antioxidant capacity in different sweet potato cultivars*. *Frontiers in Plant Science, 12*, 696142. https://doi.org/10.3389/fpls.2021.696142

[22] Zhou, Y., et al. (2024). *Volatile compounds analysis and sensory profiling of four colored roasted sweet potatoes via HS-SPME GC-O-MS and HS-SPME GC×GC-TOF MS*. Journal of Food Composition and Analysis, 131, 106256. https://doi.org/10.1016/j.jfca.2024.106256

[23] Kumar, R., Singh, A., & Sharma, P. (2023). Application of Failure Mode and Effect Analysis (FMEA) for quality and shelf-life risk assessment in food supply chains. *Journal of Food Engineering, 345*, 111320. https://doi.org/10.1016/j.jfoodeng.2023.111320