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What Are the Risks of Halal Cosmetic Products?

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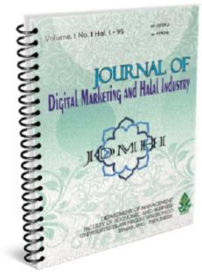
A R T I C L E I N F O



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A B S T R A C T

PT. XYZ is a company engaged in manufacturing private-label cosmetics and skin care products in Indonesia. However, of these private label or 'Maklon' products, only four of the 151 products produced by Maklon are currently available and have Halal certification. The objectives of this research are to (i) determine the critical control points that influence Halal certification, (ii) determine the level of priority in the processes required to ensure strict control procedures, and (iii) provide practical strategies to reduce the likelihood of a halal risk profile. Research reveals that, during the production of such products, the highest Halal risk arises through the potential for cross-contamination with non-Halal products during the raw material delivery process in the Supply Chain. This risk produces a Fuzzy Risk Priority Number value of 10.74, placing the birthing process in the Very High-Risk category. Therefore, it is recommended that to reduce this risk significantly, special Standard Operating Procedures are introduced by the requirements of the Halal Product Assurance System. This action will delineate between Halal and non-Halal products regarding packaging requirements and appropriate separation protocols to be implemented during delivery. Additionally, all logistics staff at the facility must be trained to competently and consistently implement these shipping and packaging requirements.

Introduction

While concern with the Halal trustworthiness of cosmetics, which Muslim consumers show, is not something new, it remains imperative that transparent standards are introduced and maintained to assure customers that there is a strict level of authenticity within the Halal Supply Chain. In this respect, the cosmetics industry has already expended much effort to guarantee that products meet Halal standards by identifying potential risks at critical points within the Supply Chain, allowing responses to be made with appropriate mitigation strategies. As with

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many products, the significant level of trust placed in Halal certification and labelling by Muslim consumers means there is considerable responsibility resting with producers to protect the Muslim faithful from consuming Haram products or other harmful ingredients prohibited by Islamic laws (Nastiti & Perguna, 2020).

Cosmetics are ready-to-use products derived from a mixture of materials and natural ingredients traditionally used externally on the body. It is well understood that these products are designed for specific purposes but are not intended to treat or cure disease (Yulia & Ambarwati, 2015). Recent records have shown that of the many cosmetic brands, both local and foreign, only around 162 have received Halal certification from the Institute for the Assessment of Food, Drugs and Cosmetics of the Indonesian Council of Ulama (LPPOM MUI). Even though cosmetic products in Indonesia have received distribution permits from BPOM, many still have not received halal certification from LPPOM MUI (Biati et al., 2022; Risdiyani, 2023). Risdiyani (2023) emphasizes this industry's importance, noting that the Halal cosmetics market grew by 6.9% over the past six years. It is thus estimated to be worth approximately $US 90 billion in 2023, a significant increase from its base of $US 61 billion in 2017. Indonesia is the second largest consumer of Halal cosmetics after India, investing $US 5.4 billion in the area, and it is estimated that the demand for Halal cosmetics will continue to increase by at least $US 3.9 billion in the next year.

PT.XYZ is a private-label manufacturing enterprise established in 2009 in Sidoarjo, East Java. PT.XYZ specializes in manufacturing quality skincare and beauty formulations, with several of these products holding Halal certification provided by the Halal Product Assurance Organizing Agency (BPJPH). Private label or Maklon products are normally manufactured on behalf of or at the special request of another party (Candra & Yuliansyah, 2022). Government sources indicate that four Maklon products have been Halal certified out of 151 Maklon products manufactured in this facility, with the remaining 97.4% not holding the appropriate certification. Given this large uncertified variance, consumers currently lack the confidence to purchase the Halal-certified Maklon products.

To provide greater consumer confidence regarding the Halal quality of certified Maklon products. It is necessary to carry out a detailed risk analysis. Such an analysis will determine the probability distribution of the outcome and the associated loss, where the outcome event is an error, and the associated loss is defined as the impact of the error (Moore et al., 2023). The Halal risk assessment conducted by the researchers supports similar manufacturing companies within Indonesia to understand production processes better and make appropriate evaluations at critical control points within the Supply Chain. As a consequence of this work, risks can be identified and solutions sought using mitigation measures.

Several methods can be used in risk analysis, one of which is Failure Mode Effect Analysis (FMEA), which uses a fuzzy logic approach. The FMEA method can identify risks and prioritize different factors based on their importance level. Moreover, it is a systematic method that identifies the real sources of a problem (Rumpuin et al., 2020). Compared to other methods, the advantage of using the FMEA method in conducting risk analysis is its ability to detect failures and assess risks

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quantitatively (H. C. Wahyuni et al., 2021). Hartanti et al. (2022) believe fuzzy logic is best deployed to analyze uncertain systems.

Further, fuzzy logic uses a scoring system that can be reflected in linguistic values based on expert field knowledge (Astuti & Mashuri, 2020). Identifying and analyzing the risks can reveal the highest risk profile, and high-risk profiles require immediate mitigation to reduce their impact. An effective technique to mitigate risk is to determine the root cause of the problem using the Fault Tree Analysis (FTA) method and then subsequently provision a solution to control the risk. FTA identifies the relationship between causal factors displayed as a Fault Tree (Wicaksono & Yuamita, 2022). The overarching purpose of this research is to determine the Halal critical points in cosmetic product manufacture, determine the priority of the cause, and provide mitigation or control mechanisms.

Literature Review

Halal Cosmetic Products

Supriyadi and Asih (2020) define 'product' as anything tangible or intangible that can be marketed and used and has value for consumers. In this respect, a product is closely related to consumers, and in this area, Muslim consumers require a guarantee of the Halal nature of the cosmetics. In Indonesia, this imprimatur is established through Halal certification via BPJH, identified by a Halal logo on the product packaging. We note that cosmetics are ingredients, or a mixture of ingredients, designed to be rubbed, glued, sprinkled, sprayed, inserted or poured on the body or parts to clean, maintain, add attractiveness or change appearance. They are not classed as medical drugs (Izza & Zavira, 2020). According to Rahayuningsih and Ghozali (2021), the qualification of Halal refers to something permissible (legal) per Islamic law. In this respect, consuming or using Halal products in the Islamic faith ensures the follower's devotion.

Risk Analysis

Risk analysis identifies and assesses possible risks within systems (Fathoni, 2020). According to Vorst et al. (2018), risk analysis refers to a series of activities designed to measure the product's exposure to the impact of risk and its likelihood. This assessment can be carried out qualitatively, semi-quantitatively or quantitatively. However, before conducting an analysis, identifying the potential risks is first necessary. According to Heriyanto and Sunreni (2020), developing an evaluation team to identify risks is critical. The team should include various investigators, including managers, employees and other relevant experts. The team will then be empowered to critically evaluate existing systems and processes with a view to their rectification once identified.

Fuzzy Failure Mode Effect Analysis

Failure Mode Effect Analysis (FMEA) identifies risks that can arise to prevent damage to processes and materials by calculating the highest priority value for each risk occurrence (Kristanto & Husyairi, 2022). This research develops conventional FMEA using the fuzzy FMEA method with accurate results. According to Hartain et al. (2022) the fuzzy concept in the FMEA algorithm provides the possibility that the data has certain attributes that can be represented linguistically or by numerical data. Islam et al. (2020) contend that this concept has some advantages, including ease of understanding, flexibility, with a tolerance for imprecise data,

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capability for modelling very complex non-linear functions, building and applying the experiences of experts without sophisticated training regimes, and working together with conventional control techniques, as it deploys natural language.

Risk Priority Number

According to Aprianto et al. (2021), the Risk Priority Number (RPN) is the priority value of risk obtained from the multiplication of the severity, occurrence, and detection levels. The results of the RPN values are then evaluated and analyzed to make corrective steps by ranking them from highest to lowest. The definitions of severity, occurrence and detection, according to Rinoza et al. (2021), are as follows: severity is the severity value of the effect caused by the failure mode on the entire system, the occurrence is a measure of how often a failure occurs, and detection is a measurement of the ability to detect or control failures that can occur.

Fault Tree Analysis

Fault Tree Analysis (FTA) is a method used to identify risks that cause failure. This method uses a top-down approach, starting with the assumption of failure from the overriding event and moving to the root cause (Kurniawan et al., 2022). According to Safrudin and Rahman (2021), the FTA method determines the factors that might cause failure, allows identification of the stages of events that might cause failure, analyzes possible sources of risk, and finally investigates the failure. Sources of risk in research, according to Kinati et al. (2020), include procedure factors, human error, faults in materials (either raw materials and additional materials), method failure (methods or processes), machine malfunction (machinery and equipment), and environment factors (work environment).

Methods, Data, and Analysis

This research uses a mixed-method approach. Qualitative methods were deployed in semi-structured interviews and questionnaires, allowing us to assess Halal risk indicators better. Halal risk indicators were also validated by the Internal Halal Coordinator (KAHI), designated as PT's responsible person. XYZ. The researchers used Fuzzy Failure Mode Effect Analysis and Fault Tree Analysis methods in the quantitative phase.

Fuzzy Failure Mode Effect Analysis Method

The following descriptions are the stages in the FMEA fuzzy process used to determine the most important level of risk. In this current study, the first stage is weighted with an assessment of severity, occurrence and detection, and details of this approach are given in Tables 1, 2 and 3.

Table 1.
Scale and fuzzy rating severity

Rating	Severity	Description	Fuzzy Number
10	Hazardous without warning	The risk of impact is very high when potential risk indicators affect the Halal status of the product without warning	(9, 10, 10)
9	Hazardous with warning	The risk of impact is very high when the potential risk indicator affects the Halal status of the product with a warning	(8, 9, 10)
8	Very high	The risk of having a very high impact on the product's Halal status	(7, 8, 9)
7	High	The risk of high impact on the product's Halal status	(6, 7, 8)

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6	Moderate	The risk may have an impact on the product's Halal status	(5, 6, 7)
5	Low	The risk of low impact on the product's Halal status	(4, 5, 6)
4	Very low	The risk of having a very low impact on the product's Halal status	(3, 4, 5)
3	Minor	The risk are less important in terms of impact on the product's Halal status	(2, 3, 4)
2	Very minor	The risk is not important in terms of the impact on the product's Halal status	(1, 2, 3)
1	None	The risk has no impact on the product's Halal status	(1, 1, 2)

Source: (Mede et al., 2021).

Table 2.

Scale and fuzzy rating occurrence

Rating	Occurrence	Description	Fuzzy Number
10 9	Almost certain (Very high)	76 - 100 % chance of risk	(8, 9, 10, 10)
8 7	High chance (High)	61 - 75 % chance of risk	(6, 7, 8, 9)
6 5 4	Moderate chance (Moderate)	51 - 60 % chance of risk	(3, 4, 6, 7)
3 2	Little chance (Low)	26 - 50 % chance of risk	(1, 2, 3, 4)
1	Infrequently (Very low)	0 - 25 % chance of risk	(1, 1, 2)

Source: (Mede et al., 2021).

Table 3.

Scale and fuzzy rating detection

Rating	Detection	Description	Fuzzy Number
10	Absolutely impossible	There are no controls to detect risk	(9, 10, 10)
9	Very remote	Very little availability of controls to detect risk	(8, 9, 10)
8	Remote	Little control to detect risk	(7, 8, 9)
7	Very low	Very low control to detect risk	(6, 7, 8)
6	Low	Low control to detect risk	(5, 6, 7)
5	Moderate	Enough control to detect risk	(4, 5, 6)
4	Moderately high	High enough control to detect risk	(3, 4, 5)
3	High	High control to detect risk	(2, 3, 4)
2	Very high	Very high control to detect risk	(1, 2, 3)
1	Almost certain	Almost certain to detect risk	(1, 1, 2)

Source: (Mede et al., 2021).

To evaluate the severity, occurrence and detection factors using a calculated fuzzy number. Factors are weighted by applying a fuzzy weight to the risk factors that arise using linguistic means, as described in Table 4.

Table 4.

Fuzzy weight risk factor severity, occurrence, and detection

Linguistic Term	Fuzzy Number
Very Low (VL)	(0; 0; 0.25)
Low (L)	(0; 0.25; 0.5)
Medium (M)	(0.25; 0.5; 0.75)
High (H)	(0.5; 0.75; 1)

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Very High (VH)	(0.75; 1; 1)

Source: (Mede et al., 2021).

The next step is to perform the first aggregation calculation, a fuzzy rating assessment of the severity, occurrence, and detection factors that refer to equations 1, 2 and 3.

$$\tilde{R}_i^S = \frac{1}{n}\sum_{j=1}^{m} h_j\,\tilde{R}_{ij}^S = \left(\sum_{j=1}^{m} h_j\,\tilde{R}_{ijL}^S, \sum_{j=1}^{m} h_j\,\tilde{R}_{ijM1}^S, \sum_{j=1}^{m} h_j\,\tilde{R}_{ijM2}^S, \sum_{j=1}^{m} h_j\,\tilde{R}_{ijU}^S\right) \quad (1)$$

$$\tilde{R}_i^O = \frac{1}{n}\sum_{j=1}^{m} h_j\,\tilde{R}_{ij}^O = \left(\sum_{j=1}^{m} h_j\,\tilde{R}_{ijL}^O, \sum_{j=1}^{m} h_j\,\tilde{R}_{ijM1}^O, \sum_{j=1}^{m} h_j\,\tilde{R}_{ijM2}^O, \sum_{j=1}^{m} h_j\,\tilde{R}_{ijU}^O\right) \quad (2)$$

$$\tilde{R}_i^D = \frac{1}{n}\sum_{j=1}^{m} h_j\,\tilde{R}_{ij}^D = \left(\sum_{j=1}^{m} h_j\,\tilde{R}_{ijL}^D, \sum_{j=1}^{m} h_j\,\tilde{R}_{ijM1}^D, \sum_{j=1}^{m} h_j\,\tilde{R}_{ijM2}^D, \sum_{j=1}^{m} h_j\,\tilde{R}_{ijU}^D\right) \quad (3)$$

Source: (Mede et al., (2021); Sucipto et al., (2018); Septifani et al., (2018).

Information:

$\tilde{R}_i^S$ = Aggregate value of severity.

$\tilde{R}_i^O$ = Aggregate value of occurrence.

$\tilde{R}_i^D$ = Aggregate value of detection.

n = Amount fuzzy number.

h_j = Respondent weight.

The second aggregation calculation determines the weight of importance for the severity, occurrence, and detection factors referring to equations 4, 5 and 6.

$$\tilde{W}^S = \frac{1}{n}\sum_{j=1}^{m} h_j\,\tilde{W}_j^S = \left(\sum_{j=1}^{m} h_j\,\tilde{W}_{jL}^S, \sum_{j=1}^{m} h_j\,\tilde{W}_{jM}^S, \sum_{j=1}^{m} h_j\,\tilde{W}_{jU}^S\right) \quad (4)$$

$$\tilde{W}^O = \frac{1}{n}\sum_{j=1}^{m} h_j\,\tilde{W}_j^O = \left(\sum_{j=1}^{m} h_j\,\tilde{W}_{jL}^O, \sum_{j=1}^{m} h_j\,\tilde{W}_{jM}^O, \sum_{j=1}^{m} h_j\,\tilde{W}_{jU}^O\right) \quad (5)$$

$$\tilde{W}^D = \frac{1}{n}\sum_{j=1}^{m} h_j\,\tilde{W}_j^D = \left(\sum_{j=1}^{m} h_j\,\tilde{W}_{jL}^D, \sum_{j=1}^{m} h_j\,\tilde{W}_{jM}^D, \sum_{j=1}^{m} h_j\,\tilde{W}_{jU}^D\right) \quad (6)$$

Source: Mede et al., (2021); Sucipto et al., (2018); Septifani et al., (2018).

Information:

$\tilde{W}^S$= The aggregate value of the fuzzy severity weight.

$\tilde{W}^O$= The aggregate value of the fuzzy occurrence weight.

$\tilde{W}^D$= The aggregate value of the fuzzy detection weight.

n = Amount fuzzy number.

h_j = Respondent weight.

Next, the value of the fuzzy risk priority number (FRPN) is determined for each existing risk using Equation 7.

$$FRPN_i = \left(\tilde{R}_i^S\right)^{\frac{\tilde{W}^S}{\tilde{W}^S+\tilde{W}^O+\tilde{W}^D}} \times \left(\tilde{R}_i^O\right)^{\frac{\tilde{W}^O}{\tilde{W}^S+\tilde{W}^O+\tilde{W}^D}} \times \left(\tilde{R}_i^D\right)^{\frac{\tilde{W}^D}{\tilde{W}^S+\tilde{W}^O+\tilde{W}^D}} \quad (7)$$

Source: Mede et al., (2021); Sucipto et al., (2018); Septifani et al., (2018).

Information:

$FRPN_i$ = Fuzzy risk priority number.

$\tilde{R}_i^S$ = Aggregate value of severity.

$\tilde{R}_i^O$ = Aggregate value of occurrence.

$\tilde{R}_i^D$ = Aggregate value of detection.

$\tilde{W}^S$= The aggregate value of the fuzzy severity weight.

$\tilde{W}^O$= The aggregate value of the fuzzy occurrence weight.

$\tilde{W}^D$= The aggregate value of the fuzzy detection weight.

Then, for the final stage, rank based on the FRPN value. The FRPN value is also called the output value of the Fuzzy FMEA, and for the level of the Fuzzy FMEA output category, refer to Table 5.

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Table 5.
Fuzzy FMEA output variable categories

Output Value	Category
1.00 - 1.99	Very Low (VL)
2.00 - 2.99	Very Low - Low (VL - L)
3.00 - 3.99	Low (L)
4.00 - 4.99	Low - Moderate (L - M)
5.00 - 5.99	Moderate (M)
6.00 - 6.99	Moderate-High (M - H)
7.00 - 7.99	High (H)
8.00 - 8.99	High - Very High (H - VH)
9.00 - 10.00	Very High (VH)

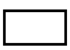
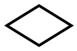
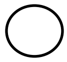
Source: (Company, 2021).

The value of the largest FRPN in the Very High (VH) category is set by PT. XYZ to be 9.00 - 10.00. This category is the top ranking that requires immediate priority attention and formulating recommendations for improvement plans. A high FRPN value for a risk indicates that the risk is classified as very high risk and is included as a priority for suggestions for improvement.

Fault Tree Analysis Method

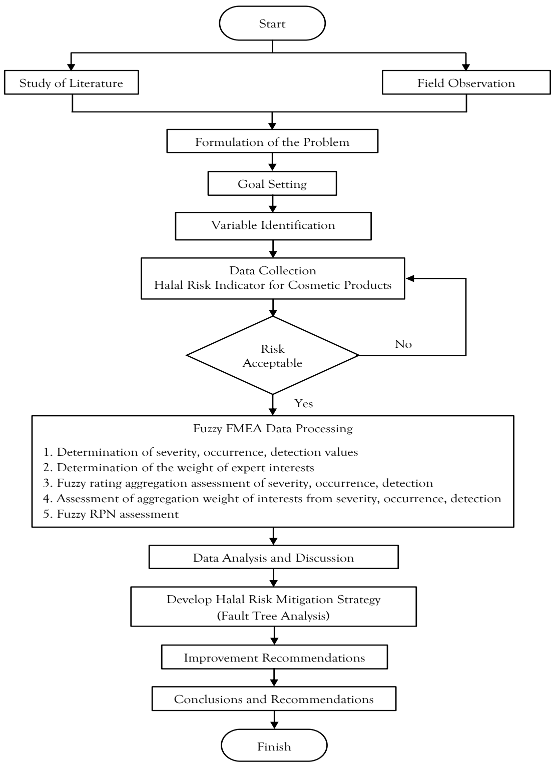
Once the results of the fuzzy risk priority number are determined through the highest FRPN value of Halal risk, an FTA analysis is carried out to produce recommendations for improvement. Kurniawan et al. (2022) outline the steps of the Fault Tree Analysis (FTA) method, which are as follows: (i) identify top-level events in the form of undesired events to identify system errors, (ii) make a Fault Tree diagram using the symbols in the FTA and (iii) analyze the Fault Tree. The symbols used for making an FTA are as shown in Table 6.

Table 6.
Symbols in fault tree analysis (FTA)

Symbol	Keterangan
	Top event: The desired event at the "peak" is further investigated in the direction of other base events by applying logic gates to determine the impact of the failure.
	Logic event OR: The logical relationship between the inputs is described in OR.
	Logic event AND: The logical relationship between the inputs is described in AND.
	Transferred event: The triangle bears the transfer symbol. This symbol ensures that the follow-up description of the event is on another page.
	Undeveloped event: Basic events will not be developed further because the information is not presented.
	Basic event: An unwanted event is considered a basic result, so no further analysis is needed.

Source: (Fatma & Putra, 2021).

Figure 1.
Research flow chart



Results and Discussion

Identification of Halal Risks in Cosmetic Products

In collecting data for identification of Halal risks, structured interviews were conducted within the organization, allowing identification of Halal risks. This procedure determined the indicators of Halal risks associated in the cosmetic Supply chain value chain at PT. XYZ. Acceptable Halal risk indicators were validated by the Internal Halal Coordinator (KAHI) regarding the Halal Product Assurance System (SJPH) criteria. Halal risk identification can be divided into six parts mentioned earlier, which are based on the source of the risk. The identified Halal risk indicators for cosmetic products are listed in Table 7.

Table 7.
Indicators of halal risk for cosmetic products

Risk Variable	Risk Indicator	Risk
Man	The halal supervisor has not followed the Halal supervisor certification by a recognized institution for every three years	Acceptable
	The value of employees does not meet the assessment standards in the evaluation of Halal training once every year	Acceptable
Material	Materials contaminated with unclean materials	Acceptable
	The new material is not registered and approved by LPPOM MUI	Acceptable
	The addition or replacement of materials has not been approved, and there is no document maintenance	Acceptable
Machine	The equipment and facilities for the production process are not specifically dedicated to producing Halal products	Acceptable
	Equipment and production facilities do not have a record of cleanliness	Acceptable
Method	The flowchart of the cosmetic production process does not comply with SJPH regulations	Acceptable
	The administrative system for storage of materials and finished products is not properly implemented	Acceptable
	The storage process or the layout for the arrangement of materials and finished products is mixed between Halal and non-Halal	Acceptable
	The delivery process is mixed with non-Halal packages	Acceptable
Environment	Means of transportation and distribution of materials or finished products are not clean and have not been cleaned	Acceptable
	The work environment is not clean and sterile which allows contamination of materials or finished products	Acceptable
Procedure	The stored raw formula is not the same as the formula used in production	Acceptable
	Receipt of incoming materials is not subject to a Halal checklist inspection	Acceptable
	Products that do not meet the criteria of being handled properly	Acceptable

Based on the results of the interviews, 16 indicators of Halal risk were identified in the cosmetic manufacturing Supply Chain. The human resources variable has two risk indicators, the material variable has three risk indicators, the machine variable has two risk indicators, the method variable has four risk indicators, the environment variable has two risk indicators, and the procedure variable has three risk indicators.

Fuzzy Failure Mode Effect Analysis Data Processing

Determination of severity, occurrence, and detection weights.

Halal risk analysis, the Fuzzy FMEA method calculates the severity, occurrence and detection weights of the questionnaire assessed by two competent respondents. The first respondent was from the Internal Halal Coordinator (KAHI) section, and the second was from the Quality Control Manager (QC) section. The two respondents are weighted based on competence (Sucipto et al., 2018). The first respondent is given a weight of 60%, and the second is given 40%. The weight of the first responder is larger since it involves specialist understanding and direct responsibility for ensuring Halal quality for cosmetics at PT. XYZ. The company's General Manager determined the weighting of the two respondents. The results of the questionnaire assessment were then converted into appropriate FMEA language, then from this linguistic form were used to determine the value of the fuzzy number assigned to each Halal risk that exists at PT. XYZ. The results of weighting severity, occurrence, and detection, along with FMEA linguistic values, can be observed in Table 8.

Table 8.
The results of weighting severity, occurrence, and detection

Variable	Risk Indicator	Code	S	O	D	Linguistic Value		
						S	O	D
Man	The halal supervisor has not followed the Halal supervisor certification by a recognized institution for every three years	R1	6	5	5	M	M	M
		R2	6	7	4	M	H	MH
	The value of employees does not meet the assessment standards in the evaluation of Halal training once every year	R1	6	8	3	M	H	H
		R2	6	7	3	M	H	H
Material	Materials contaminated with unclean materials	R1	10	7	3	HWOW	H	H
		R2	10	10	2	HWOW	VH	VH
	The new material is not registered and approved by LPPOM MUI	R1	10	5	3	HWOW	M	H
		R2	8	8	3	VH	H	H
	The addition or replacement of materials has not been approved and there is no document maintenance	R1	8	7	5	VH	H	M
		R2	8	8	4	VH	H	MH
Machine	The equipment and facilities for the production process are not specifically dedicated to producing Halal products	R1	10	8	3	HWOW	H	H
		R2	8	8	3	VH	H	H
	Equipment and production facilities do not have a record of cleanliness	R1	8	8	5	VH	H	M
		R2	7	7	4	H	H	MH
Method	The flowchart of the cosmetic production process does not comply with SJPH regulations	R1	6	5	3	M	M	H
		R2	8	8	3	VH	H	H
	The administrative system for storage of materials and finished products is not properly implemented	R1	6	8	5	M	H	M
		R2	6	7	4	M	H	MH
	The storage process or the layout for the	R1	8	8	5	VH	H	M

	arrangement of materials and finished products is mixed between Halal and non-Halal	R2	8	8	3	VH	H	H
	The delivery process is mixed with non-Halal packages	R1	8	8	6	VH	H	L
		R2	6	7	5	M	H	M
Environment	Means of transportation and distribution of materials or finished products are not clean or cleaned	R1	7	3	2	H	L	VH
		R2	7	6	3	H	M	H
	The work environment is not clean and sterile which allows contamination of materials or finished products	R1	8	4	2	VH	M	VH
		R2	7	7	3	H	H	H
Procedure	The stored raw formula is not the same as the formula used in production	R1	10	5	4	HWOW	M	M H
		R2	8	8	3	VH	H	H
	Receipt of incoming materials is not subject to a Halal checklist inspection	R1	7	5	3	H	M	H
		R2	7	6	3	H	M	H
	Products that do not meet the criteria of being handled properly	R1	10	8	4	HWOW	H	M H
		R2	8	7	3	VH	H	H

Calculation of fuzzy aggregation rating severity, occurrence and detection.

At this stage, to produce an aggregation fuzzy rating value, the fuzzy number value was multiplied by the weight of each respondent, then averaged to get the fuzzy rating aggregation value from severity ($\tilde{R}_i^S$), occurrence ($\tilde{R}_i^O$), and detection ($\tilde{R}_i^D$) relevant to each Halal risk indicator. The results of calculating the fuzzy aggregation rating severity, occurrence, and detection can be seen in Table 9.

Table 9.

The results of the calculation of the fuzzy rating aggregation from severity, occurrence, and detection

Risk Indicator	$\tilde{R}_i^S = \frac{1}{n}\sum_{j=1}^{m} h_j \tilde{R}_{ij}^S$			$\tilde{R}_i^S$	$\tilde{R}_i^O = \frac{1}{n}\sum_{j=1}^{m} h_j \tilde{R}_{ij}^O$				$\tilde{R}_i^O$	$\tilde{R}_i^D = \frac{1}{n}\sum_{j=1}^{m} h_j \tilde{R}_{ij}^D$			$\tilde{R}_i^D$
The halal supervisor has not followed the Halal supervisor certification by a recognized institution for every three years	5	6	7	6	4.2	5.2	6.8	7.8	6	3.6	4.6	5.6	4.6
The value of employees does not meet the assessment standards in the evaluation of Halal training once every year	5	6	7	6	6	7	8	9	7.5	2	3	4	3
Materials contaminated with unclean materials	9	10	10	9.7	6.8	7.8	8.8	9.4	8.2	1.6	2.6	3.6	2.6
The new material is not registered and approved by LPPOM MUI	8.2	9.2	9.6	9	4.2	5.2	6.8	7.8	6	2	3	4	3
The addition or replacement of materials has not been approved and there is no document maintenance	7	8	9	8	6	7	8	9	7.5	3.6	4.6	5.6	4.6

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The equipment and facilities for the production process are not specifically dedicated to producing Halal products	8.2	9.2	9.6	9	6	7	8	9	7.5	2	3	4	3
Equipment and production facilities do not have a record of cleanliness	6.6	7.6	8.6	7.6	6	7	8	9	7.5	3.6	4.6	5.6	4.6
The flowchart of the cosmetic production process does not comply with SJPH regulations	5.8	6.8	7.8	6.8	4.2	5.2	6.8	7.8	6	2	3	4	3
The administrative system for storage of materials and finished products is not properly implemented	5	6	7	6	6	7	8	9	7.5	3.6	4.6	5.6	4.6
The storage process or the layout for the arrangement of materials and finished products is mixed between Halal and non-Halal	7	8	9	8	6	7	8	9	7.5	3.2	4.2	5.2	4.2
The delivery process is mixed with non-Halal packages	6.2	7.2	8.2	7.2	6	7	8	9	7.5	4.6	5.6	6.6	5.6
Means of transportation and distribution of materials or finished products are not clean or cleaned	6	7	8	7	1.8	2.8	4.2	5.2	3.5	1.4	2.4	3.4	2.4
The work environment is not clean and sterile which allows contamination of materials or finished products	6.6	7.6	8.6	7.6	4.2	5.2	6.8	7.8	6	1.4	2.4	3.4	2.4
The stored raw formula is not the same as the formula used in production	8.2	9.2	9.6	9	4.2	5.2	6.8	7.8	6	2.6	3.6	4.6	3.6
Receipt of incoming materials is not subject to a Halal checklist inspection	6	7	8	7	3	4	6	7	5	2	3	4	3
Products that do not meet the criteria have not been handled properly	8.2	9.2	9.6	9	6	7	8	9	7.5	2.6	3.6	4.6	3.6

Calculation of the aggregation of importance weights from severity, occurrence and detection.

Calculate the aggregation of importance weights on the severity, occurrence and detection factors. Experts in the Halal field determine the weighting of each factor. The weight value for each factor has five levels of linguistic value (or 'fuzzy weight'), namely Very Low (VL), Low (L), Medium (M), High (H) and Very High (VH). After determining the linguistic value of each factor, it can then be converted into a fuzzy number. The next stage is the multiplication of fuzzy numbers and known respondent weights. Following this multiplication, results are averaged to produce an aggregation of importance weights from severity ($\widetilde{W}^S$), occurrence ($\widetilde{W}^O$), and detection ($\widetilde{W}^D$). The results of calculating the importance of weight aggregation from severity, occurrence and detection can be observed in Table 10.

Table 10.

The results of the calculation of the importance of weight aggregation from severity, occurrence and detection

Factor	Code	W	Rating	FN			W x FN			$\tilde{W}^S$
Severity	R1	0.6	VH	0.75	1	1	0.45	0.6	0.6	
	R2	0.4	H	0.5	0.75	1	0.2	0.3	0.4	
			Total				0.65	0.9	1	0.85
Occurrence	R1	0.6	M	0.25	0.5	0.75	0.15	0.3	0.45	
	R2	0.4	H	0.5	0.75	1	0.2	0.3	0.4	
			Total				0.35	0.6	0.85	0.6
Detection	R1	0.6	M	0.25	0.5	0.75	0.15	0.3	0.45	
	R2	0.4	H	0.5	0.75	1	0.2	0.3	0.4	
			Total				0.35	0.6	0.85	0.6

Calculation of Fuzzy Risk Priority Number (FRPN)

The final stage for estimating Fuzzy FMEA is determining the Fuzzy RPN value. This value is obtained by dividing the values of $(\tilde{W}^S)$, $(\tilde{W}^O)$ and $(\tilde{W}^D)$ by the total of the three importance weights, then multiplied the result by the values $(\tilde{R}_i^S)$, $(\tilde{R}_i^O)$ and $(\tilde{R}_i^D)$. Finally, the results of the three factors are multiplied to get the Fuzzy RPN value. The results of the Fuzzy RPN calculation can be observed in Table 11.

Table 11.

The results of FRPN calculations

Risk Indicator	$(\tilde{R}_i^S)\frac{\tilde{W}^S}{\tilde{W}^S+\tilde{W}^O+\tilde{W}}$	$(\tilde{R}_i^O)\frac{\tilde{W}^O}{\tilde{W}^S+\tilde{W}^O+\tilde{W}}$	$(\tilde{R}_i^D)\frac{\tilde{W}^D}{\tilde{W}^S+\tilde{W}^O+\tilde{W}^I}$	FRPN	Rating
The halal supervisor has not followed the halal supervisor certification by a recognized institution for every 3 years	2.49	1.76	1.35	5.88	10
The value of employees does not meet the assessment standards in the evaluation of halal training once every 1 year	2.49	2.20	0.88	4.80	12
Materials contaminated with unclean materials	4.01	2.40	0.76	7.32	7
The new material is not registered and approved by LPPOM MUI	3.73	1.76	0.88	5.75	11
The addition or replacement of materials has not been approved and there is no document maintenance	3.32	2.20	1.35	9.80	2
The equipment and facilities for the production process are not specifically dedicated to producing halal products	3.73	2.20	0.88	7.19	8
Equipment and production facilities do not have a record of cleanliness	3.15	2.20	1.35	9.31	3
The flowchart of the cosmetic production process does not comply with SJPH regulations	2.82	1.76	0.88	4.35	13
The administrative system for storage of materials and finished products is not properly implemented	2.49	2.20	1.35	7.35	6
The storage process or the layout for the arrangement of	3.32	2.20	1.23	8.95	4

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materials and finished products is mixed between halal and non halal					
The delivery process is mixed with non halal packages	2.99	2.20	1.64	10.74	1
Means of transportation and distribution of materials or finished products are not clean and clean from uncleanness	2.90	1.02	0.70	2.09	16
The work environment is not clean and sterile which allows contamination of materials or finished products	3.15	1.76	0.70	3.89	14
The stored raw formula is not the same as the formula used in production	3.73	1.76	1.05	6.90	9
Receipt of incoming materials is not subject to a halal checklist inspection	2.90	1.46	0.88	3.73	15
Products that do not meet the criteria have not been handled properly	3.73	2.20	1.05	8.63	5

Based on the FRPN calculation results detailed in Table 11, the three highest Halal risk ratings according to company standards are 9.00 - 10.00. The highest risk is the delivery process mixed with non-Halal packages with a value of 10.74, which is consequently included in the Very High (VH) risk category. The second highest risk is the addition or replacement of materials that have not been approved, and there is no document maintenance. This yields a value of 9.80 and is included in the Very High (VH) risk category. The third highest risk is equipment and production facilities that do not have a record of cleanliness, which gives a value of 9.31 and is thus included in the Very High (VH) risk category.

Preparation of Halal Risk Mitigation Strategy with Fault Tree Analysis

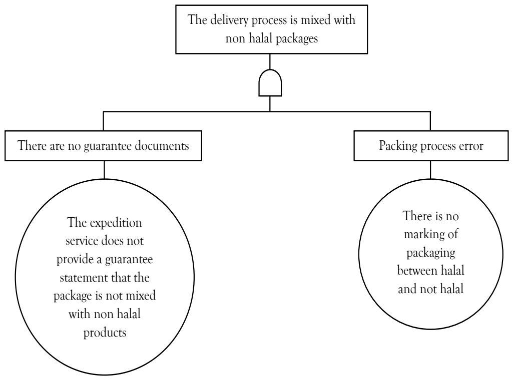
After conducting a Fuzzy FMEA analysis, the next step is to analyze to provide improvements based on the three Halal risks with the highest FRPN values using the FTA method. Figures 2, 3 and 4 show the FTA diagram of these values.

The delivery process is mixed with non-Halal packages

The following is an FTA diagram of the delivery process is mixed with non-Halal packages.

Figure 2.

FTA diagram of the delivery process mixed with non-halal packages.



Based on the diagram above, it can be seen that the top event of Halal risk for cosmetic products is "the delivery process mixed with non-Halal packages", which has two intermediate events and two basic events. Two factors cause the potential cause of this risk, these being (i) the lack of consistency and accuracy of documentation and (ii) packing process errors. Further, no verification statement affirms that the package has not been mixed with non-Halal products. In addition, the packing process

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currently has no clear marking on the packaging informing the consumer of the level of segregation of Halal-certified products.

The addition or replacement of materials has not been approved, and no document maintenance exists.

The following is an FTA diagram of the addition or replacement of materials that have not been approved and for which there is no document maintenance.

Figure 3.
FTA diagram of the addition or replacement of materials has not been approved, and there is no document maintenance

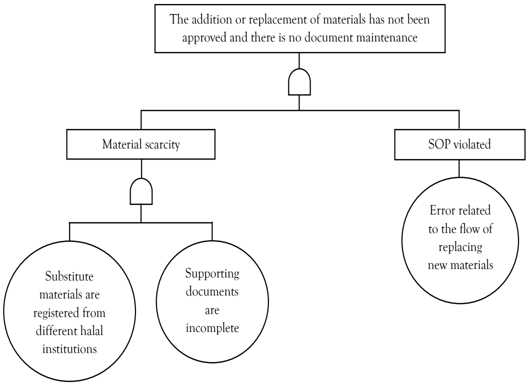

Figure 3 shows that the top event of Halal risk for cosmetic products is "the addition or replacement of ingredients has not been approved and there is no document maintenance". This has two intermediate events and three basic events. The potential cause of this risk is caused by two factors, which are (i) material scarcity and (ii) Standard Operating Procedure (SOP) violation. The material scarcity factor is due to substitute materials registered from different Halal institutions, for which the supporting documents are often incomplete. The SOP factor is a non-compliance step which arises from an error related to the flow of replacement materials.

Equipment and production facilities do not have a record of cleanliness

Figure 4.
The FTA diagram of the equipment and production facilities does not have a cleanliness record.

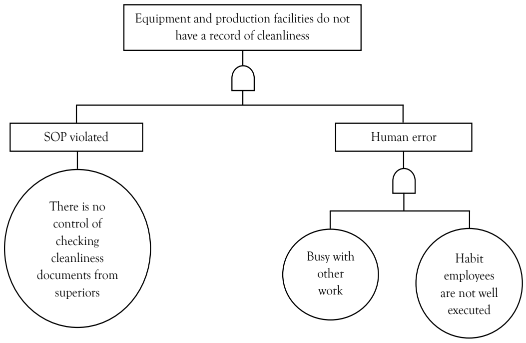

Figure 4 above shows that "equipment and production facilities do not have a record of cleanliness", which has two intermediate and three basic events. The potential cause of this risk is caused by two factors, namely SOP non-compliance and human error. The SOP illuminated the lack of checking controls, including specialized documentation affirming the materials' cleanliness. No formal steps are available to complete the cleanliness documentation before shipping.

Improvement Recommendations

As a result of the research and analysis conducted by the researchers, recommendations have been made to mitigate and better control risk. These recommendations are listed in Table 12.

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Table 12.
Results of recommendations for improvement

Top Event	Intermediate Event	Basic Event	Improvement Recommendations
The delivery process is mixed with non halal packages	There are no guarantee documents	The expedition service does not provide a guarantee statement that the package is not mixed with non-Halal products	Make improvements to the shipping SOP according to SJPH (Hosianna et al., 2021)
	Packing process errors	There is no marking on the packaging for halal products with products that are not Halal	It is given a partition that distinguishes between Halal and non Halal products (Ariffien et al., 2019)
			Do a check before shipping (A. E. Wahyuni & Rais, 2019)
The addition or replacement of materials has not been approved and there is no document maintenance	Material scarcity	Substitute materials are registered from different Halal institutions	Do a search on the BPJH website to see if halal institutions from outside are recognized in Indonesia (Susanto et al., 2022)
		Supporting documents are incomplete	Checking the completeness of supporting documents for raw materials (Izzah & Rozi, 2019)
	SOP violated	Error related to the flow of replacing new materials	Perform SOP improvements related to the flow of replacement of new materials (Hosianna et al., 2021)
Equipment and production facilities do not have a record of cleanliness	SOP violated	There is no control of checking cleanliness documents from superiors	Conduct SOP education regarding the cleanliness of production equipment and facilities (Azis & Vikaliana, 2023)
	Human error	Busy with other work	Reaffirm the employee's job desk (Izzah & Rozi, 2019)
		Cleanliness habits of employees are not well executed	Motivate employees well so that their work habits are more positive (Azis & Vikaliana, 2023)
			Give strict sanctions if bad habits are carried out continuously (Azis & Vikaliana, 2023)

Conclusion

Based on these research results, it can be concluded that there are 16 critical points of concern for ensuring Halal quality cosmetics found within the manufacturing Supply Chain Chain based on indicators of Halal risk. Prioritization of the three highest FRPN values, which are (i) the delivery process, which has the potential to allow mixing of Halal and non-Halal products, (ii) the addition or replacement of materials which does not require appropriate approvals which becomes evident due to the lack of document maintenance, and (iii) equipment and production facilities used within the facility do not have the required cleanliness records. Therefore, in order to mitigate and or control cross-contamination risks, PT. XYZ must (i) urgently rectify existing SOPs in accordance with Halal certification guidelines, (ii) introduce a significant tightening of every

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stage of the inspection process to ensure they accord to Halal principles, (iii) implement an organizational re-training program particularly for dispatchers and (iv) provide a comprehensive training program which must be developed by newly developed SOPs for personnel involved in onboarding materials.

Based on the results of this research, the theoretical and practical implications are as follows. for theoretical implications, these findings indicate that the halal risk analysis of cosmetic products with the fuzzy FMEA method provides accurate results compared to the conventional fMEA method. With the fuzzy FMEA method, the highest FRPN value is produced where the risk priority is in accordance with the conditions in the company, this is due to the involvement of the assessment by experts in their field. So the fuzzy FMEA method can provide appropriate improvements to halal risks. For practical implications, the results of this study can be used as input for companies and can be implemented by halal supervisors in analyzing halal risk using the fuzzy FMEA method and using the FTA method in developing halal risk mitigation strategies in companies.

Suggestion

Based on the findings of this research, recommendations for improvement are that companies should strictly implement SOPs because SOPs are important guidelines for every production process, tighten the inspection process in every production process related to halal, and give strict sanctions to workers if errors occur and provide work motivation. Recommendations for further research should be to analyze halal risks in cosmetic products by processing data using Matlab software.

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