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APPLICATION OF FMEA METHOD IN HALAL RISK DETERMINATION ON HALAL POULTRY SLAUGHTERING OPERATIONS

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ABSTRACT

Halal slaughtered chicken has become crucial in globalization and complex supply chains. The rising awareness among Muslim communities regarding the integrity of slaughtered chicken products has led to a focus on adhering to halal compliance standards and Islamic law. This study aims to qualitatively analyze the halal risk points in chicken slaughtering operations using the Failure Mode and Effect Analysis (FMEA) method to identify potential halal risks and ensure the integrity of halal chicken products. This qualitative study uses an analytical approach by examining secondary sources, including journals, articles, guidelines, and standards related to the halal slaughtering process. In this study, seven Halal Risk Points (HRP) have been identified in the entire halal slaughtering process of broilers. Based on the risk assessment results through the FMEA method, each determined HRP will be assessed based on the severity, occurrence and detection rating scale. The final result of this study found that only six HRPs have a Risk Priority Number (RPN) value that exceeds 100. Therefore, corrective action recommendations are proposed to prevent any halal non-compliance from occurring in the process involved. Overall, the FMEA framework in this study is a new approach to guaranteeing the integrity of chicken slaughter products and can positively impact the halal chicken slaughter industry players and the implementers of the halal management system.

Keywords: *Halal slaughtered chicken, Failure Mode and Effect Analysis, Halal Risk Point, Risk Priority Number, Halal non-compliance.*

1. INTRODUCTION

The consumption of halal slaughtered chicken is an important focus in life, especially for Muslim communities. This significance extends beyond compliance

with religious requirements but also encompasses health, cleanliness, and overall social well-being. Islam strongly emphasizes the consumption of halal and good food, and a deep understanding of the process of chicken slaughter according to Islamic law is crucial to ensuring the halal status of the meat source (Tuan et al., 2018). Thus, the provision and use of halal slaughtered chicken are not merely ritualistic actions but also reflect a comprehensive concern that can bring goodness and health to individuals and Muslim communities alike, whether from a physical, mental, emotional, or spiritual perspective (Hayat et al., 2023).

In the era of globalization and increasingly complex chicken supply chains, a profound understanding of the importance of halal slaughtered chicken becomes even more crucial. According to Razaly & Zakaria (2018), the rising awareness among Muslim communities regarding the status and integrity of slaughtered chicken products also leads to a similar ripple effect in adhering to halal compliance standards and meeting the requirements of Islamic law. Therefore, the importance of halal slaughtered chicken not only focuses on religious aspects but also plays a significant role in shaping dietary patterns and daily lifestyles, which is a responsibility for every Muslim individual to practice the concept of *Halalan Tayibba* (HT) by adhering to the requirements of Islam itself.

Issues surrounding chicken slaughter in Malaysia have recently sparked concern and debate among Muslim consumers, particularly in the state of Penang. Allegations include the use of counterfeit halal logos and the employment of non-Muslim slaughterers in chicken slaughterhouses, alongside reports of inadequate cleanliness standards in the production process (Zuhainy, 2023). Instances of non-compliance with hygiene standards during slaughter, lack of accreditation for slaughterers, and poor sanitation have led to the closure of slaughterhouses in Batu Caves and Cheras, Kuala Lumpur (Mohd Jamilul Anbia, 2022; Jaafar, 2022). Concerns extend to the market, where doubts arise about adherence to Islamic slaughter practices, prompting inspections by the State Religious Department of Perak to ensure halal compliance (Sinar Harian, 2023). A local newspaper also reported that nearly 80% of chickens slaughtered in 2000 slaughterhouses nationwide had doubtful halal status. This occurred due to weaknesses and negligence in the industry, particularly in adhering to cleanliness and halal slaughter requirements according to existing laws. This made processed chickens considered doubtful by Muslim consumers (Zainudin, 2014).

In the context of HT, Mohd Al' Ikhsan et al. (2022) explained that the process of slaughtering chickens must comply with the concept of *tayyib* (food safety) and the conditions set in the Islamic law as stated in the Qur'an (Devine book) and Hadith sources (Actions and sayings of the Prophet Muhammad, peace and blessings be upon him). In terms of halal management, the implementation of halal control points (HCP) at each step or process, for example, is stated in the Malaysian Halal Certification Procedure Manual (MHCPM) and the Malaysian Halal Management System (MHMS)

manual developed by the Department of Islamic Development Malaysia (JAKIM) in 2020. This requires the development of a comprehensive Halal Assurance System (HAS) documentation system (JAKIM, 2020a; 2020b). Additionally, to strengthen the halal assurance in slaughter products, compliance with the prerequisites for halal slaughter is guided by the Halal standard MS1500:2009 (General Guidelines for the Production, Preparation, Handling and Storage of Halal Food-second revision) published by the Malaysian Standards Department-DOSM (2009).

The determination of halal non-compliance risks often utilizes methods such as the 'Halal Decision Tree Analysis,' derived from the Hazard Analysis Critical Control Point (HACCP) system (Kohilavani et al., 2012; Omar et al., 2012), and the 'Halal Control Point Risk Matrix Assessment,' adoption from the Malaysian Halal standard MS2400-1:2019 (Department of Standards Malaysia, 2019b; Ramli et al., 2023). This systematic approach, as elucidated by Mohd Hasli (2022) and Ramli et al. (2023), involves clear and systematic processes to evaluate the likelihood of haram occurrences at each step of an activity or process rather than relying on conjecture. However, using the 'Failure Modes and Effects Analysis' (FMEA) approach to assess halal risks, particularly in commercial chicken slaughtering, remains underexplored (Nuchpho et al., 2019). FMEA methods offer a systematic strategy for identifying potential halal risks and implementing mitigating measures to safeguard the integrity of halal products. This study aims to explore the activities of the commercial halal slaughtering chicken process and propose potential halal risk point (HRP) involvement analyzed using the FMEA framework, starting before live chickens are slaughtered until they are processed into raw meat products. This approach represents a novel contribution to halal assurance management systems.

2.0 LITERATURE REVIEW

2.1 *Halalan Tayyiba Concepts*

From the Islamic perspective, consuming halal and wholesome food obeys Allah the Almighty's command and benefits human physiology from physical, emotional, and spiritual aspects (Md Dalal, 2021). Islam has urged mankind to fulfil the responsibilities as commanded in the sources of the Quran to avoid any harm or evil originating from food sources. Based on the verse from the Quran in Surah *Al-Mu'minun*, verse 51, it is evident that the Quran clearly explains the obligation to seek and consume halal and good food. This is in line with what is commanded by Allah the Almighty in Surah Al-Baqarah, verse 168, which means:

> *"O ye apostles! enjoy (all) things good and pure, and work righteousness: for I am well-acquainted with (all) that ye do."*
>
> (Surah Al-Mu'minun 23:51)

and,

> *"O ye people! Eat of what is on earth, Lawful and good; and do not follow the footsteps of the evil one, for he is to you an avowed enemy"*
>
> (Surah Al-Baqarah 2:168)

Based on the above Quranic verse, it is clear that the expression of the verse is a call involving all human beings on the face of the earth and is not specific to followers of Islam or otherwise. This matter refers to the gift of God's grace that encompasses all human beings to eat halal and wholesome food sources and prohibits humans from consuming prohibited food. This is because the food sources prohibited by Him can harm health and damage one's intellect (Muhamed & Muhammad Shafiai, 2021).

Halalan tayyiba (wholesome) food is closely related to clean, pure, and safe-to-eat food. These three aspects complement each other to fulfil the requirements of Islamic law and the command of Allah the Almighty, as found in the Quran. In this context, there are several views on the concept of HT. According to Wahbah Az-Zuhayli (1991), *halalan tayyiba* refers to food that contains no doubtful elements (*syubhah*) and is not sinful if consumed. On the other hand, Yusuf al-Qaradawi (2000) states that halal refers to what Allah the Almighty permits, while tayyib refers to something permissible that does not harm the human body and mind. Ishak et al. (2018) mentioned that halal pertains to matters that Muslims must safeguard and prioritise in matters related to consumption. Meanwhile, '*tayyiba*' implies food that is not impure in its content, not spoiled, or mixed with impurities. Therefore, the concept of HT in food sources begins with the raw materials used, preparation methods, packaging, equipment, and storage (Mohamad et al., 2015). Overall, when all stages of food production are free from forbidden and doubtful elements, it becomes halal, clean, pure, and safe to eat. However, this food concept must align with the advancement of food technology, which also involves halal and haram status in food, purity, safety, compliance with food standardization levels, and side effects on human health.

2.2 *Halal Slaughter According to Islamic Perspective*

The definition of slaughter refers to an action carried out to end the life of an animal to be a food source (Merriam-Webster, 2024). In terminology, it means a method of killing animals for consumption by draining blood from the blood vessels in the neck using a sharp instrument such as a knife (Abdul Munir & Nordin, 2021). Meanwhile, from the perspective of Islamic Sharia law, slaughter means the act that severs the trachea (*halqum*), esophagus (*mari'*), and both the carotid arteries and jugular veins (*wadajain*) to expedite bleeding and death of the animal using a sharp tool with the intention due to Allah the Almighty (DOSM, 2009, 2019a; JAKIM, 2020b). In the context of Islamic slaughter, it is obligatory to perform it on an animal to permit it to be halal for consumption. Animals not slaughtered according to Islamic law are

referred to as carrion and impure. Therefore, this matter becomes a duty for Muslims as a whole to obtain lawful meat sources by slaughtering animals based on the demands of the Quran. This aligns with the Islamic teaching stance on what is permissible and prohibited, particularly concerning the consumption of meat, as stated by Allah the Almighty in Surah Al-Ma'idah verse 3, Al-An'am verses 121 and 145, which means:

> "*Forbidden to you (for food) are dead meat, blood, the flesh of swine...*"
>
> Al-Ma'idah (5:3)

In another verse, Allah SWT said,

> "*Eat not of (meats) on which Allah.s name hath not been pronounced: That would be impiety. But the evil ones never inspire their friends to contend with you. If ye were to obey them, ye would indeed be Pagans*".
>
> Al-An'am (6:121)

and,

> It means, "*Say: "I find not in the message received by me by inspiration any (meat) forbidden to be eaten by one who wishes to eat it, unless it be dead meat, or blood poured forth, or the flesh of swine,- for it is an abomination – or, what is impious, (meat) on which a name has been invoked, other than Allah.s". But (even so), if a person is forced by necessity, without wilful disobedience, nor transgressing due limits,- thy Lord is Oft-forgiving, Most Merciful*".
>
> Al-An'am (6:145)

Based on the above Quran verse, it is evident that Islamic teachings emphasize the obligation to mention the name of Allah when slaughtering halal animals. However, this aspect of slaughtering is carried out with several benefits from both the Shariah legal and scientific perspectives. From a Shariah legal standpoint, Yusuf al-Qaradhawi (2019) elucidates that the wisdom behind slaughter is also a means of showing respect for Allah's creatures by fostering kindness towards animals and cultivating a good spirit. Furthermore, halal slaughter serves to differentiate between Shariah-compliant animal slaughter and that of non-Muslims. From a scientific perspective, it is found that animals slaughtered according to Islamic recommendations yield higher quality meat and also influence the shelf life of the meat obtained (Abdul Munir & Nordin, 2021).

Sahid & Awang (2020) found that the Islamic method of slaughtering is the best and also conforms to the requirements of the *tayyib*a concept (cleanliness). This is because immediately after the slaughtering of the animal, blood flows out and the meat becomes cleaner and safer to eat for humans. Furthermore, Abd El-Rahim et al. (2023)

found that the results of Islamic slaughtering make the meat tenderer compared to meat not slaughtered according to Islam. This is evidenced in an *IslamOnline* article (2023), reporting that a study from a university in Germany conducted experiments to determine the level of pain when slaughtering animals using conventional methods and sharp knife tools. Through these experiments, it was found that the Islamic slaughtering process showed that the slaughtered animals experienced a deep sleep-like state and were not conscious. Therefore, it can be concluded that this method causes the animals to experience no pain when slaughtered. In contrast, a modern method of slaughter, through the 'Captive Bolt Pistol Stunning', results in animals experiencing extreme pain, which contradicts the concept of animal welfare in Islam.

From a food safety perspective, Hayat et al. (2023) stressed that animal blood is a primary medium for the proliferation of microorganisms capable of jeopardizing human health. Furthermore, the authors elucidate that halal slaughter will affect the meat's pH level and glycogen content, affecting its tenderness, colour, and the number of bacteria in the meat. Therefore, it can be concluded that there are numerous benefits behind the injunctions and prohibitions from Allah the Almighty to humanity regarding the consumption of halal meat sources. Overall, halal slaughter is not only a religious requirement but also a practice that can have positive implications not only in terms of food safety but also aligns with the dictates of Islamic law while aiding in avoiding harm, whether physical, mental, emotional, or spiritual to humanity.

2.3 *Commercial Processing Of Halal Chicken Slaughter*

Generally, the halal animal slaughtering process, particularly for broiler chickens, involves specific steps that must be meticulously followed, adhering to the principles and requirements of Islamic Sharia law. However, not only is cleanliness emphasized during the slaughtering and carcass processing of chickens, but other factors such as processing temperature, bleeding time, scalding process temperature, and storage are also taken into account to ensure that the resulting chicken slaughter products comply with the concepts of HT. In the research context, commercial chicken slaughtering operations, primarily conducted at slaughterhouse premises, encompass several activity steps, from poultry care on the farm to live chicken reception before slaughter until raw chicken is processed into downstream products or directly marketed in the market. However, this study only discusses and focuses on the activities of chicken slaughtering and carcass processing, and further determination of HRP can be systematically conducted through the FMEA framework. Therefore, a process flowchart has been developed to clearly understand the chicken slaughtering process until the chicken carcass is processed, as illustrated in Figure 1.

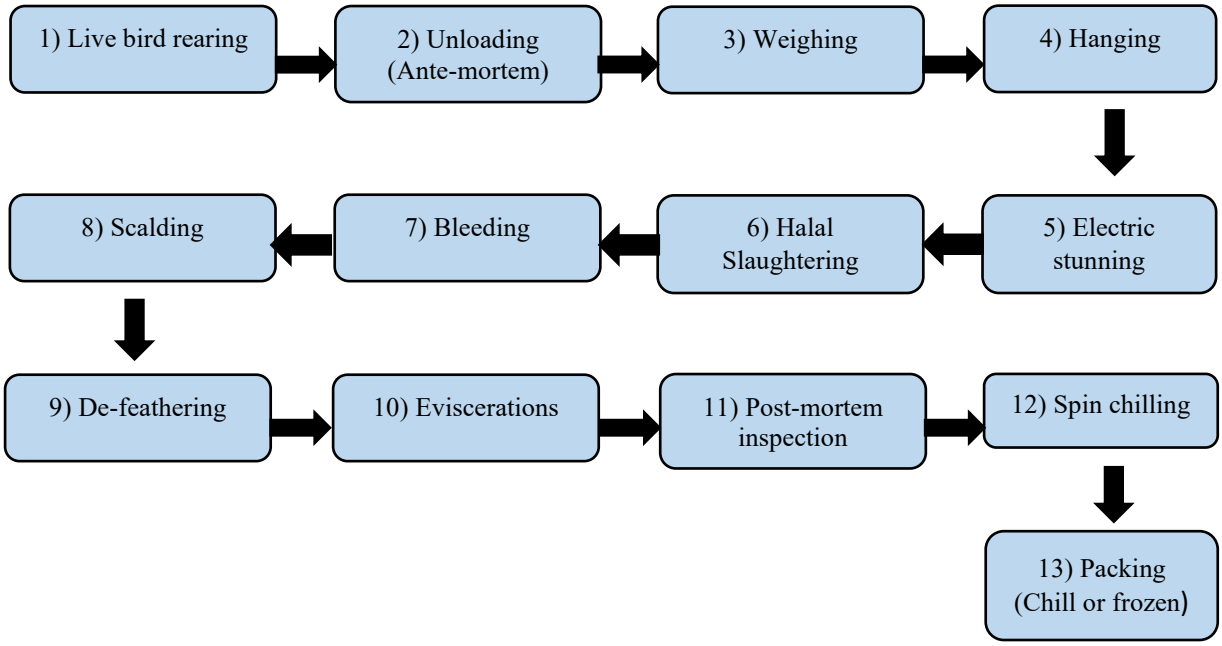

Figure 1. Commercial chicken broiler slaughtering process flow chart.

Based on Figure 1 above, 13 steps of activities in the chicken slaughtering and carcass processing process are involved and focused on in this study. Among the initial steps is the stage of chicken farming on commercial farms. In this phase, the care of broiler chickens will be managed and maintained until they reach optimal body weight before being sent to commercial slaughterhouses. In addition, farm management, such as feeding, watering, and medication sources for animal health management, are also essential aspects and priorities in chicken farm operations. Past studies by Omar et al. (2012) emphasise that the chicken farming phase in the field is a potential halal risk. According to the author's findings, farm location, animal welfare practices, chicken feed sources, and medication are critical halal points that must be scrutinized. Similarly, Ramli et al. (2023) and Shahdan et al. (2016) emphasize that the chicken farming stage is among the potential halal control points that may affect halal non-compliance. The factors involved are chicken breed selection, chicken coop facilities, feed sources, and medication that may affect the halal integrity of chicken slaughter products. The following process involves 'ante-mortem' inspection, which refers to examining live chickens before slaughter to check for any signs of disease or infection symptoms in chickens. Early inspection aims to prevent cross-contamination during the later processing of the chicken carcass.

The process of weighing live chickens is carried out to ensure they meet the required weight for the slaughterhouse. After weighing, the live chickens are hung upside down using a shackle machine to facilitate slaughtering. Following this, the chickens undergo an electrical stunning process involving immersing them in a water bath with a low electrical current to calm them before slaughter. According to the halal standard MS1500:2009, it has been recommended that the ideal electrical current for the

stunning process of chickens is between 0.20 and 0.60 Amperes (A), and the required voltage current ranges from 2.50 to 10.50 volts for 3 to 5 seconds. However, the voltage amount applied to live chickens depends on the weight of the chickens to be slaughtered (DOSM, 2009). Nevertheless, based on previous findings, there are differing views on using electrical current for this stunning process. This is evidenced by the study conducted by Shahdan et al. (2016), which explained that using an electrical current of 0.105A for stunning proved that the risk of chickens experiencing death is low. Furthermore, nearly 90% of stunned chickens regain consciousness when subjected to electrical shock. Additionally, using a high electrical current for stunning (0.125A) indicates that the blood flow after slaughter is slower than the current strength of 0.05A. Therefore, in this regard, it is evident that the electrical current must be used appropriately within the time frame according to the type of animal and body size to prevent them from experiencing death. Thus, in the context of halal slaughter, if the electrical current applied is high, it may cause paralysis or heart failure. This results in the slaughtered animal being classified as carrion and deemed unlawful for consumption by Muslims (Tuan Sidek & Ridzwan, 2023).

After the chicken undergoes the stunning process, it will be slaughtered according to the requirements and conditions that comply with Islamic Sharia law. Among them, the animal to be slaughtered must be of halal status and tame or capable of being controlled by humans. As elucidated in MS1500:2009, another requirement for valid slaughter is that the slaughterer must be a Muslim citizen of Malaysia and possess a recognized slaughterer certificate from the relevant authority, such as the State Department of Islamic Religion in Malaysia. Furthermore, the animal to be slaughtered must be healthy and disease-free. In the context of halal, Tuan Sidek & Ahmad (2023) affirm that among the prerequisites of live chickens before slaughter, they must be in a state of '*haya al-mustaqirrah,' referring to the condition of the slaughtered animal still* alive when blood is drained during slaughter or the presence of animal movements.

Additionally, the method of slaughter, as prescribed by the Islamic religion, is a means to expel as much blood as possible from the slaughtered animal's body. Therefore, severing the trachea (*halqum*), esophagus (*mari'*), and both the carotid arteries and jugular blood veins (*wadajain*) is mandatory to enable the blood from the brain and heart to flow out (Shahdan et al., 2016). According to the Islamic perspective, one of the main objectives of the slaughtering process is to ensure that the life of the animal can be taken quickly. In this regard, it is in line with the Islamic principles of avoiding the torture of animals to be slaughtered and practising animal welfare (Sahid & Awang, 2020). In another context, according to Yusuf al-Qaradhawi (2019) also opined that this halal slaughter is also clearly intended to differentiate the slaughter process between Muslims and the *'Jahilliyah*' (Non-Muslim) community who offer the meat of livestock for their idols. Accordingly, this halal slaughtering process is not merely to

kill it but rather to ask permission from Allah SWT to slaughter the animal for consumption.

Next, another requirement before slaughtering a live chicken is to recite '*tasmiyyah*'. *Tasmiyyah* refers to the act of saying the words '*Bismillah Allahuakbar*,' which means "In the Name of Allah, Allah the Most Great," and also '*Bismillahirrahmanirrahim*,' which means "In the name of Allah, the Most Gracious and Most Merciful" (Tuan Sidek & Ahmad, 2018). The recitation of '*tasmiyyah*' during slaughter is highly emphasized in the Quranic verses that mention the command to recite *tasmiyyah* as stated in Surah *Al-Maidah* verse 4, Surah *Al-Haj* verse 34, Surah *Al-An'aam* verses 119 and 138. According to Wahbah al-Zuhaily (1999), the *Shafi'i* school of thought views omitting the recitation of '*tasmiyyah*' during slaughter as a disliked act. If done intentionally, the slaughterer is considered to have sinned. Additionally, in the MS1500:2009 standard, it is stated that slaughtering chickens is recommended to be done facing the '*qiblah*' direction and using clean and sharp knives.

The next step involves bleeding activity after the chicken is slaughtered to remove blood from the chicken's body before the chicken carcass is passed into the scalding machine to facilitate the chicken feather removal process. Tuan Sidek and Ahmad (2018) explained that bleeding is essential. It is not only focused on removing blood from the body of the slaughtered chicken, but it is also in line with the wisdom of prohibiting the source of flowing blood as stated in the Word of Allah SWT in Surah *al-Maidah* verse 3, which means prohibiting blood in the food sources of humanity. Therefore, it is reasonable for this bleeding process to take place so that the final product of raw chicken is clean and free from any contamination of harmful microorganisms to meat products.

The study by Hakim et al. (2020) and Al-Shammari (2021) indicates that removing blood from chicken carcasses can reduce the risk of contamination by pathogenic microorganisms such as *Coliform*, *E.coli*, and *Salmonella* in the meat. According to Hakim et al. (2020), a quantitative study on non-halal slaughtered chickens showed significantly higher levels of bacteria count, especially the Total Plate Count (TPC), than halal slaughtered chickens. Kilci et al. (2023) also support this point, stating that chicken carcasses still containing blood pose a risk of bacterial infection. *E.coli* and *Staphylococcus aureus* infections are among the risks, causing diarrhoea, meningitis, septicemia, and chronic food poisoning in humans. Additionally, halal slaughtering methods significantly extend the shelf life of meat. Therefore, this study concludes that the halal slaughter method, according to Islam, is the best method to produce halal, clean, and high-quality chicken meat. It also aligns with the concept of *maqasid al-shariah* to protect human life and promote the consumption of HT food.

Subsequently, after the hot water scalding process and chicken feather removal are completed, the chicken carcass will undergo the evisceration process, where the

chicken's internal organs are removed. In addition, post-mortem inspection is also carried out. This post-mortem inspection involves checking the condition of the chicken carcass to meet specifications, namely, being free from any disease infection. If there are signs of infection, the chicken carcass is separated and disposed of as it is feared to affect human health (Jalil & Qamar, 2019). After the post-mortem examination, the chicken carcass undergoes a cooling process by immersing it in cold water below 4ºC. Commercially, this process involves using a semi-automation machine known as 'spin chilling'. The chicken carcass cooling process aims to minimize bacterial growth that can deteriorate meat quality and thus increase the shelf life of the carcass. Finally, before being marketed, the chicken carcass will be packaged and stored in a chill room below 4ºC or a freezer room below -30ºC.

2.4 *Halal Risk Assessment and FMEA Method*

In halal risk assessment, several assessment methods are employed to determine the potential degree of risk of contamination of haram substances in processing operations or activities. Among these, Omar & Jaafar (2011) and Omar et al. (2012, 2013) studies have developed the Halalan Tayyiban Critical Control Point (HTCCP) by adapting the Hazard Analysis and Critical Control Points (HACCP) food safety system to identify potential halal non-compliance in the meat industry supply chain through interview methods. From the authors' findings, it is noted that the identified HTCCP has not been comprehensively implemented. Conversely, Kohilavani et al.'s (2012, 2015) study uses a combined approach of halal concepts and the HACCP system to determine the Halal Critical Control Point (HCCP) for chicken slaughtering operations. In Kohilavani et al. (2015, 2021) studies, one of the methods used involves employing the 'Halal Critical Control Point Decision Tree- HCCPDT' to assess the potential risks in chicken slaughtering processing. According to their findings, this HCCPDT consists of a series of questions acting as a primary guide to determine whether each involved process step is a critical halal point or not.

In other words, this HCCPDT methodological approach is similar to developing preliminary steps and the seven principles of the HACCP system in identifying food hazard contamination.

On the other hand, Shahdan et al. (2016) approach to halal critical point assessment differs slightly from the researchers mentioned earlier. Before utilizing the 'Halal Control Point Decision Tree' method, the assessment of each chicken slaughtering process will be categorized based on Sharia law from Quranic and Hadith sources such as *Fardhu'* (obligatory/compulsory), *Mandhub* (desirable), *Mubah* (neither recommended nor prohibited), *Makrooh* (detested), and *Haram* (prohibited). However, in Mohd Hasli (2022) and Ramli et al. (2023) studies, which focus on determining HCCP in the poultry farming sector on the farm, the 'Halal Control Point Risk Matrix Assessment' is used to assess and identify the involved HCPs. Their study classified

initial-stage activities such as feeding, medication sources, logistics, and animal welfare before slaughtering as HCCP. As previously explained, this study will employ the FMEA methodological approach as the primary focus to assess the degree of risk in halal chicken slaughtering operations. Generally, the use of FMEA applications dates back to the early 1960s in the aerospace and automotive industries. FMEA has been utilized in food safety implementation, especially in manufacturing. The FMEA method is generally used to help determine, identify, prioritize and eliminate any potential risk of failure in the manufacturing process before the product is marketed to customers (Wessiani & Yoshio, 2018). So, the main objective of using FMEA in halal risk management is to prevent any potential halal non-compliance and further increase halal product integrity, especially in slaughtered chicken meat.

Pop et al. (2019) conducted research that used the FMEA method to produce meat sausage products. According to them, combining the HACCP system and the FMEA method is not only focused on determining the potential hazards that hurt human health. However, improving food products' quality and safety level is also essential. Meanwhile, Aleksic et al. (2022) also emphasized that through the FMEA method, the assessment aspect of the probability of risk hazards in dairy production can also be accurately assessed, and the potential existence of risk can be prevented entirely. Therefore, this study will not only delve into the entire operation of commercial chicken slaughtering, but the researcher will interpret the potential halal risk and evaluate it by producing a 'Risk Priority Number' (RPN) value and then mitigation measures and preventive actions are developed so that halal risk can be prevented entirely. In the meantime, a new structured and systematic approach involving the FMEA method and RPN calculation can not only identify and reduce potential risks. It can also improve the slaughtered broiler chicken's reliability, safety and halal integrity.

In addition, this study can also reflect on implementing more efficient and sustainable halal management to comply with the requirements of the HT concept. Overall, from the discussion and explanation in this study, seven HRP recommendations have been identified in the commercial halal chicken slaughtering operation. The seven HRPs proposed in this study cover the chicken care phase in the livestock farm, the chicken hanging process, the electric stunning process, the halal slaughtering stage, the bleeding process, evisceration, and the spin-chilling process.

3. MATERIAL AND METHODS

In this study, we use a qualitative research approach and the document analysis method to examine each step of the halal chicken slaughtering process and identify potential hazards in each activity. To achieve the objectives of this case study, we will analyze secondary literature materials such as reputable journals and articles about halal slaughtering practices, as well as methods of determining halal non-compliance.

We will also review guidelines, halal standards, and references from the Quran and relevant Islamic legal rulings (fatwas) concerning the Islamic jurisprudence of slaughtering. Additionally, we will identify and evaluate potential risks, such as biological, chemical, and physical hazards, that could lead to halal and food safety risks. This study aims to minimize or eliminate the probability of potential halal risk using the FMEA methods. Before evaluating and determining the halal risk points (HRP) in the FMEA method, several processes must be carried out step by step to take corrective action against the identified HRPs. The FMEA method is commonly used in the manufacturing industry to identify potential risks and reduce the occurrence of failures, thus minimizing the impact of product failures. However, this method requires meeting several criteria. When measuring the level of halal risk in the context of the halal chicken slaughtering process, the necessary criteria include severity (S), occurrence (O), and detection (D). These three levels of the value scale can be explained as follows.

3.1 *Severity (S):*

In this context, the degree of severity refers to the first step taken to analyze the risk by identifying the risk impact that will affect the outcome of the process. As such, the severity of this risk is analysed qualitatively by involving a rating scale from 1 to 10. A value of 10 is the worst impact. The level of risk covers four levels, which are insignificant to the critical level where each slaughtering process involved is evaluated in terms of severity, which can affect the integrity of HT, as shown in Table 1.

3.2 *Occurrence value (O):*

As for the occurrence, there is the possibility that the frequency of the cause of risk will occur and produce a form of contamination of non-compliance with either halal integrity or toyyiba during the ongoing process of the activity. Regarding setting the rating scale, the degree of occurrence is represented with a scale of 1 to 10, the highest value scale at a critical level, indicating that the frequency of potential risk occurring is higher, as shown in Table 2.

3.3 *Detection value (D):*

The last variable, the rating of detection, refers to the ability to detect the probability of a particular risk or control causal factors that may occur during the activity. The detection scale is evaluated on a scale 10, representing the slightest chance to detect potential halal risks before they occur, as shown in Table 3. Suppose the detection level of a processing activity cannot be identified or detected. In that case, attention should be paid to the control of the process, as contamination or non-compliance with halalan tayyiba has a high potential to occur.

Table 1. Severity rating scale used in FMEA methods

Assessment rating	Level of risk	Assessment criteria (Severity level)- S
9 -10	Critical	There is haram contamination according to Sharia law on animal husbandry or product processing activities that have the potential to affect the overall halal product harm to humans, and the effect of the halal status of the product or livestock product cannot be saved. There is a very high potential for it to have a negative impact on a business or organization.
7 - 8	High	Non-compliance with Sharia law will affect the integrity of halal tayyiba and increase the potential for consumers, the public, and the authorities to lose trust in the halal status.
5 - 6	Moderate	Non-compliance with hygiene and cleanliness will affect the integrity of the tayyib aspect, and consumers, the public, and the authorities may lose trust in products and/or livestock products.
1 - 2	Insignificant	There is no direct impact on products and/or livestock products or risk of non-compliance with the halalan tayyib status.

Table 2. Occurrence rating scale

Assessment rating	Level of risk	Assessment criteria (Occurrence level)- O
9 -10	Critical	The potential for halal non-compliance is very high and unavoidable.
7 - 8	High	The potential for halal non-compliance often occurs frequently.
5 - 6	Moderate	The potential for halal non-compliance occurs occasionally.
3 - 4	Low	Potential halal non-compliance is relatively rare.
1 - 2	Insignificant	Potential halal non-compliance is unlikely to occur.

Table 3. Detection rating scale

Assessment rating	Level of risk	Assessment criteria (Detection level)- D
9 -10	Critical	Process controls will likely not be able to detect halal non-compliance.
7 - 8	High	The probability of halal non-compliance not being detected is high.
5 - 6	Moderate	The potential for halal non-compliance is not detected at a moderate level.
3 - 4	Low	The probability of potential non-compliance with halal not being detected is low.

1 - 2	Insignificant	Process controls can almost certainly detect potential halal non-compliance.

The FMEA method defines the risk level based on the RPN value from each risk. If the value of RPN is higher, then the risk will increase. Obtaining the RPN involves calculating it by multiplying the values of the three variables using the formula (RPN= S x O x D). Typically, the RPN values obtained from the calculation above, the sum of these multiplications will be evaluated in decreasing priority order, arranged from the highest to the lowest values. In this case, the acceptance of the targeted maximum RPN value, which is 100, aims to reduce and prevent the impact of HT risk. Suppose the total RPN for each analyzed process or activity exceeds the set RPN target of more than 100. In that case, the process will then be categorized as high potential for halal risk, and subsequently, mitigation steps or corrective action strategies will be implemented. Finally, the assessment results elaborated in the following steps will be documented and presented in the FMEA framework as the study findings in evaluating the potential halal risk and mitigation steps to prevent non-compliance with halal standards in the chicken slaughtering and processing process.

4. RESULTS AND DISCUSSION

A systematic approach using the FMEA method to determine the level of halal risk is considered a new approach to evaluating and determining the level. The following section will discuss the seven HRPs identified in the FMEA framework. Each HRP is discussed by (1) what is the potential risk of failure, (2) the potential impact of the risk if it occurs, (3) factors that are causing the risk, (4) process control to prevent any halal risk and finally (5) recommend a correction actions. In addition, within the FMEA framework, risk assessment based on the rating scale is also done together in this FMEA, as shown in Table 4.

4.1 *HRP 1: Live Bird Rearing*

The first identified halal risk point occurs at the phase of broiler chicken care in commercial farm fields. One of the elements leading to potential non-compliance is the farm's location. The broiler chicken farm location should be distant from pig farms. As stated in the MS1500:2019 halal standard, processing activities or premises should be far from pig farms to prevent potential contamination. The raw material content in broiler chickens' feed and medication sources also plays a crucial role. According to Ali Rao (2020) and Mohd Ashraf & Abd Rahman (2018), the source of animal feed is a crucial factor in ensuring that chicken meat produced using the Halal Tayyib concept is safe for consumption by the Muslim community. They highlighted potential halal risks, such as feed containing illegal substances, medicated additives, heavy metals, mycotoxins, pesticide residues, and genetically modified feed (GMF) that could negatively impact animals and humans. Therefore, raw materials used in feed and

medication sources must not contain any substances or doubtful elements in Islam that could compromise the halal integrity of the slaughtered meat. Furthermore, among the potential risks in logistic activities is the risk of contamination/mixing of halal and non-halal substances. Therefore, it is recommended that only halal animal transportation be used in delivery activities. Animal welfare practices, such as ensuring chickens' comfort during transportation, also play a crucial role. In this regard, if hot environmental temperatures cause chickens to experience stress, the risk of death increases. Therefore, at this stage, the severity level is assessed as critical (ranked 8th), and the occurrence level is at 9 (critical level). Meanwhile, the obtained RPN value is 504. Thus, the pre-slaughter chicken activities should be classified as the first HRP.

4.2 *HRP 2: Chicken Hanging*

Furthermore, hanging chickens before entering the electric stunning process is considered the second highest risk point (HRP). Based on the risk assessment results, the severity and detection levels all fall within level 6. From a halal perspective, the chicken hanging process on the conveyor shackles must be performed flawlessly to ensure that both legs are not injured. The study of Zulkfili et al. (2019) supports hanging chickens through this shackle. They state that chicken shackling is essential in taking care of animal welfare by preventing pain in live chickens before the stunning process. Additionally, they emphasize that this shackling process aims to reduce vigorous struggling and wing flapping, which can cause injury to the chicken's body. Chao (2022) and Shahdan et al. (2016) also state that this process is a critical aspect of halal that should be carefully considered, as it can affect the emotional well-being and respect for animals and the quality of the meat produced. This aligns with the proper treatment of live animals under Islamic welfare practices and closely relates to the concept of tayyib, ensuring the quality and safety of slaughter products. Any injuries sustained during the hanging process may lead to bruises (blood clots within muscle tissue), compromising consumer trust and confidence in the product (Chao, 2022). Hence, related procedures or SOPs should be developed, and training should be scheduled for employees to reduce risks effectively.

4.3 *HRP 3: Electric stunning*

The third halal risk point involves the electric stunning process. According to the HACCP quality system, this stunning process is not emphasized as one of the critical control points requiring strict monitoring activities to ensure food safety. From a halal perspective, the stunning process is a critical point that requires unique and stringent attention to ensure that chickens passing through the water bath with a specific electrical current do not become the primary cause of death before slaughter. Tuan Sidek & Ahmad (2023) state that if an electrical current during the stunning process that does not meet the standards causes the dead chicken to be slaughtered before it

is considered forbidden (*haram*) to be consumed by Muslims. This aligns with the command of Allah SWT in the Qur'an, surah al Maidah verse 3, which clearly states that animals that are not slaughtered (carcasses) are prohibited in Islamic law. As explained in previous sections, industry practice's ideal electrical current is between 6 to 10 volts for 3 to 5 seconds. In this regard, only Muslim supervisors or workers who are competent are fully responsible for monitoring the amount of electrical current used throughout the stunning process. Additionally, appointed Halal Executives are responsible for inspecting and ensuring that chickens subjected to water bath stunning are in good condition and do not pose harm to living chickens before slaughter.

4.4 *HRP 4: Halal Slaughtering*

The highest RPN value obtained in halal slaughtering activity is 800. From the perspective of Islamic law, among the obligatory aspects of the slaughtering process are the severing of the *halqum, mari'*, and two jugular veins. Furthermore, the slaughterman must recite the '*tasmiyyah*' verse, which distinguishes between Muslim and non-Muslim slaughter. Considering other requirements in this aspect of slaughtering, the valid condition for slaughtering is that the slaughterman must be a Muslim and a Malaysian citizen (according to MS1500), the animal being slaughtered must have *'hayah al-mustaqirrah'*, and finally, the animal must be halal for consumption by Muslims. Specific requirements include using a sharp knife, the slaughterman and the animal facing the qiblah direction. In terms of food safety, slaughtering practices not only serve as a command from Allah Almighty as instructed in the Quran but also have various benefits. Among these is removing blood from the chicken's body, resulting in cleaner meat and preventing the potential contamination of pathogenic microorganisms, thereby ensuring food safety. This is because, from an Islamic perspective, flowing blood is considered impure. Overall, industry players should pay special attention to this slaughtering activity to ensure the integrity of the slaughtered meat products.

4.5 *HRP 5: Bleeding Process*

The bleeding process after the chicken is slaughtered is also classified as the fifth HRP in the slaughter operation. This activity involves the removal of blood until all the blood in the chicken's body is expelled, which is crucial to the concept of *tayyiba*. This is because blood in the meat negatively affects the quality of chicken meat and human health. In the operation of chicken slaughter, the required bleeding time typically depends on the size and distance of the shackle conveyor. The ideal bleeding time is less than 4 minutes to completely drain all blood before the chicken carcass undergoes scalding for easier feather removal. Through risk assessment, the obtained RPN value for this process is 120, which is lower than other HRPs. However, corrective actions such as monitoring bleeding time must be sufficient and thorough to ensure clean meat and longer meat storage life.

4.6 *HRP 6: Evisceration*

The next halal risk point involves the evisceration process, which involves removing the viscera (internal organs and intestines) from the birds. This process can be automated, semi-automated, and manually, with the workers' use of tools such as knives or scissors. Mohd Hasli (2022) and Ramli et al. (2023) emphasise the importance of removing chicken internal organs such as intestines and crops to prevent any microbial contamination of meat products. This is particularly crucial as residues in the crop could potentially lead to microbiological contamination of meat products post-evisceration. Therefore, a post-mortem examination is conducted to detect disease symptoms early on to ensure it does not affect meat quality. In the context of halal risk level, researchers argue that this operation step does not involve halal risk but instead focuses on food safety (*tayyiba*) aspects, which aim to prevent cross-contamination or the spread of diseases to humans. Thus, based on the halal risk level perspective, this step is viewed as more oriented towards ensuring meat quality assurance and does not lean towards the risk of haram contamination.

4.7 *HRP 7: Spin Chilling*

The seventh and final HRP identified involves cleaning and chilling chicken carcasses, commonly known as the spin chilling process. Based on the scale rating calculations obtained, the resulting RPN value is 100. Generally, this spin-chilling process is the final step before chicken carcasses are wrapped and stored in a chilled or frozen state. This operation uses clean water and ice to clean the chicken carcasses and lower the carcass temperature below 4ºC. This is because the specified low temperature is associated with food safety, where if meat products exceed 4ºC, bacterial proliferation occurs, consequently reducing the product's storage life. For instance, meat products commonly exhibit spoilage effects such as greenish skin or flesh, mucus excretion, and a rancid odour due to bacterial growth. Therefore, the cold water temperature used in the spin chiller must be monitored to ensure that the resulting raw halal slaughtered chicken products comply with the HT concepts. In addition to water and ice, chlorine solution (Cl2) kills bacteria and acts as a chicken carcass cleaning agent. Consequently, the use of chlorine chemicals must comply with the established procedures in terms of the concentration levels used. However, if the chlorine concentration exceeds the limit, it will affect the colour and odour quality of the meat. Meanwhile, if chlorine is below 20 ppm, pathogenic microorganisms may contaminate chicken carcasses during the spin chilling. Moreover, high chlorine levels can also affect worker safety by negatively impacting the human respiratory system when exposed to high chlorine gas concentrations. From another perspective, this aspect of worker safety aligns with the application of the *maqasid al-shariah* concept, where Islamic teachings emphasize prioritizing five criteria: preserving religion, life, intellect, lineage, and property that benefit humans in this world and the hereafter (Tuan Sidek & Ahmad, 2018; 2023). Therefore, in this spin chilling process, researchers

believe that the process is closely related to the implementation of the *tayyib*a concept because it has a negative impact on the quality of chicken meat and food safety levels.

Based on the above discussions, this study has determined the level of risk assessment for each identified HRP that impacts the halal status of chicken slaughter products. Consequently, the RPN assessment for each HRP will be arranged according to decreasing ranking values. As explained in the previous topic, each HRP with the highest value should be critically addressed, and appropriate corrective actions should be taken by industry players in implementing halal management systems, especially for commercial halal slaughter operations. A concise table outlining the RPN values from highest to lowest can be presented in Table 5.

Table 4. Proposed FMEA Framework For Halal Chicken Slaughtering Operations

HRP	Process	Potential failure risk	Potential risk effects	S	Potential cause of risk	O	Process control	D	RPN value	Recommended corrective action
1	Live bird rearing	The location of the chicken farm is close to the pig farm.	The risk of non-halal contamination from pig farms.	8	Less exposure to the requirements of halal standards.	9	Awareness training for livestock farm management and slaughterhouse premises.	7	504	Complies with the requirements of MHMS JAKIM and MS 1500 standards.
		Sources of poultry feed and medicine are contaminated with non-halal elements.	The halal integrity of meat products is compromised.		No halal control monitoring/ halal internal audit.		Internal halal audit on the supply of animal feed sources.			Conduct an internal halal audit from the slaughterhouse management to check and monitor the source of feed supply and medicinal materials. A DNA detection test of feed by a recognized laboratory.
		Using non-halal transport. Live chickens suffer from heat stress and emotional disturbances while in the basket.	There is a risk of cross-contamination of non-halal elements, chickens' death, and meat quality slaughter.		Lack of monitoring and absence of SOP by Halal Executive.		Effective dosing procedures and periodic schedules. Internal halal audit on logistics transportation.			Carry out an internal halal audit from the slaughterhouse management to inspect and monitor the process of providing medication and logistic activities for transporting poultry.

HRP	Process	Potential failure risk	Potential risk effects	S	Potential cause of risk	O	Process control	D	RPN value	Recommended corrective action
							Procedures and records of lairage activity monitoring.			Perform efficient and effective animal welfare practices.
2	Chicken Hanging	The chicken will be physically injured if it is not hung perfectly. Not implementing the practice of animal welfare in Islamic teachings.	Affecting the quality of chicken carcasses. Able to disturb the emotions of livestock.	6	Lack of regular training in animal welfare practices. Intentionally injuring poultry.	6	Training on handling or the process of hanging chickens effectively regularly. Practising good animal welfare practices.	6	216	Training procedures and records related to animal welfare practices.
3	Electric stunning	Chickens die before slaughter. Does not meet MS1500 and MHMS JAKIM standard requirements.	Chicken carcasses become forbidden to consume. Violating Islamic Shariah law and complying with Malaysia's halal standards requirements.	8	Electric current that exceeds the specified limit. The operator controls the stunning machine by a non-Muslim worker.	6	The control and monitoring of the stunning level electrical control panel. Ideal stunning electric current: 6 to 10 volts	8	384	Have an update scheduled for monitoring and supervision by a supervisor or Muslim employee only.
4	Halal slaughtering	The trachea (*halqum*), esophagus (*mari'*), and both the carotid arteries and	Slaughter products have a non-halal status according to Shariah law in Islam.	10	The knife used is not sharp and the Muslim slaughterer is not competent and	10	Make sure the knife used is sharp and clean.	8	800	Adequate slaughter knife inspection record.

HRP	Process	Potential failure risk	Potential risk effects	S	Potential cause of risk	O	Process control	D	RPN value	Recommended corrective action
		jugular veins (*wadajain*) are not entirely cut.			does not have a slaughtering competency certificate from the halal authority.		The slaughterer must be recognised as a competent slaughtering by a halal authority.			The slaughtering competency certificate is constantly updated. The slaughterhouse company conducts an internal halal audit on a scheduled basis.
		Chicken carcass status is haram to eat.	Slaughter halal animals in the name of anyone/anything except Allah.		Not recites '*Tasmiyya*h' and not facing the direction of '*qiblah*' Slaughter from non-Muslims.		Have competency halal training. Slaughter competency certificate from a halal authority.			Scheduled halal competency training. An internal halal audit from the slaughterhouse company.
		Cross-contamination from pathogenic microorganisms.	Chicken carcasses' cleanliness and food safety do not meet the required standard specifications.		The condition of the slaughter knife was not clean and perfect.		Have a sound water flow system to wash the knife when you slaughter the chicken.			Maintenance records of knife tools and the water pipe system in the chicken slaughterhouse. Procedures/SOPs for using knife tools that are updated by halal standards.

HRP	Process	Potential failure risk	Potential risk effects	S	Potential cause of risk	O	Process control	D	RPN value	Recommended corrective action
		Farm chickens are infected with zoonotic diseases.	Affects the quality and tayyiba aspect of chicken carcass products and human health.		Not performing the 'ante mortem' inspection process effectively.		Updating ante mortem inspection records before chickens are slaughtered.			Monitored by the company's quality assurance department and veterinary authorities.
5	Bleeding process	Cross-contamination of pathogenic microorganisms from the blood source occurs.	Affecting the quality of the chicken carcass and human health. It does not comply with Islamic law because blood is impure in Islam.	6	Bleeding time after slaughter is insufficient.	5	Monitor the duration of the bleeding process from the moment the chicken is slaughtered until the blood comes out completely from the chicken's body. The Shackle conveyor is in normal condition and operating optimally.	4	120	Efficient bleeding time record. Scheduled shackle conveyor maintenance records.
6	Evisceration	The chicken's internal organs, i.e., intestines, were found broken. Internal organs i.e: chicken crop have feed.	Cross-contamination from pathogenic microorganisms occurs. Affects the quality and tayyiba aspect of chicken carcass products.	5	The eviscerator machine is not working correctly. No effective monitoring and post-mortem inspection.	5	The eviscerator machine is maintained on a scheduled basis. Updated evisceration procedure/SOP.	2	50	Effective machine maintenance records. Records of the evisceration process are updated and monitored by the company's quality department.

HRP	Process	Potential failure risk	Potential risk effects	S	Potential cause of risk	O	Process control	D	RPN value	Recommended corrective action
		There is no separation of chicken carcasses if there are symptoms of disease infection.			The cleanliness level of the eviscerator machine is not satisfactory.		Procedures/SOPs for effective equipment cleaning activities.			Laboratory analysis results (Swab analysis).
7	Spin chilling	The internal temperature of the chicken carcass does not reach the set chill temperature. The level of chlorine content in the chill water exceeds the permitted standard.	The shelf life of chicken carcasses is shorter. Does not meet the standard specifications of the microbiological standard.	5	The temperature of the chicken carcass does not reach below 4ºC. Chlorine content in water exceeds 20 ppm or less than 20 ppm.	5	Adequate capacity of water and ice is monitored at all times. Procedures/SOPs related to preparing chlorine chemicals into spin chiller machines.	4	100	Records of inspection and preparation of quantities of water and ice. Monitoring and inspection of the level of chlorine content in water by the company's quality department. Microbiological lab reports.

Table 5. Summary of RPN values for each HRP of halal slaughtered chicken activities

HRP no.	Process	RPN value
4	Halal slaughtering	800
1	Live bird rearing	504
3	Electric stunning	384
2	Chicken Hanging	216
5	Bleeding process	120
7	Spin chilling	100
6	Evisceration	50

5. CONCLUSION AND FUTURE RECOMMENDATION

The issue of obtaining halal sources of meat is widely discussed and also a polemic issue for the Muslim community, especially in Malaysia. In the aspect of halal slaughtering, particularly for animals deemed halal, it is extensively elucidated as per the commandments of Allah Almighty in the Quran and also from Hadith sources. In the increasingly modern and up-to-date technological era, the poultry slaughtering industry, such as chicken processing, has also been influenced by semi-automatic slaughtering technology compared to traditional methods. In the context of halal management, slaughterhouses operating must obtain halal slaughter certification from JAKIM. This ensures that chickens are slaughtered following Shariah law and pays attention to *tayyiba* (wholesomeness). Various risk assessment systems or identification of critical halal points have been developed regarding halal assurance, such as the Hazard Analysis Critical Control Point (HCCP) plan to determine critical halal points used in commercial chicken slaughtering operations. However, this study has taken a new approach to assessing halal risk in chicken slaughtering operations using the Failure Mode and Effect Analysis (FMEA) method. The study findings found that all halal risk points (HRP) except for the evisceration process should be emphasized or, more precisely, scrutinized to ensure the integrity of chicken slaughter outputs. Implementing this FMEA framework provides a platform to elucidate potential risk occurrences and potential causes of risks but is also considered a clearer assessment of halal risk points. However, this study's findings only focus on a qualitative approach. Therefore, this research paper can be further improved by conducting empirical analysis by analyzing the frequency of non-compliance incidents with halal standards and food safety aspects and using Pareto analysis and FMEA to ensure a more detailed and in-depth assessment of halal risk in halal slaughtering operations.

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