# Potential Risk of Work Accident in The Production Process of Gudeg Chicken using The Failure Mode and Effect Analysis (FMEA) Method

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**Abstract**

*Every agricultural industry has a potential risk of work accidents, one of which is at the Micro, Small and Medium Enterprises (MSMEs) level in Yogyakarta. Gudeg producers as one of the MSMEs in the traditional culinary also have various types of work accident risks in their production process, including in the process of producing Gudeg Chicken. Overall, the process of producing Gudeg Chicken includes sorting, washing, cooking, and distribution. The results of the initial observations indicated that workers in sorting division had the complaints of back pain and several work accidents have occurred in the production division of Gudeg Chicken. Hence, it is deemed necessary to analyze the risk of work accidents occurred. The analysis of work accident risks was done using the Failure Mode and Effect Analysis (FMEA) method by considering severity, occurrence, and detection values to obtain a Risk Priority Number (RPN). The results were then analyzed using a Pareto diagram to determine the work accident with the highest risk. Recommendations for improvement were given using the Hazard Identification Risk Assessment and Risk Control (HIRARC). The results showed that the highest risk of work accidents was related to the position of sitting that is not ergonomic in the process of sorting Gudeg Chicken. The elimination of these risks does not need to be carried out, but it needs to do substitution of production areas, engineering controls with modifications towards the tables or chairs of employees, administrative controls, and the use of Personal Protective Equipment.*

**Keywords:** *Gudeg Chicken, FMEA, HIRARC, work accident*

## 1. INTRODUCTION

Micro, Small and Medium Enterprises (MSMEs) becomes one of the growing businesses, as found in agricultural sector including culinary. In Special Region of Yogyakarta, the number of MSMEs in agricultural sector reached 1,249 units in 2021 (Office of Cooperatives and MSMEs of Special Region of Yogyakarta, 2022). One of the growing MSMEs in the Special Region of Yogyakarta that has received considerable concern and is highly favored by tourists is *Gudeg* - a typical culinary heritage made from young jackfruit and cooked in coconut milk. *Gudeg* is usually consumed with other foods as the complement to side dishes. Side dishes such as eggs, chicken, *Krecek* chilli sauce, cassava leaves, tempeh and tofu were served as the complementary with the *gudeg* (Kurniawati and Marta, 2021). The combination of *gudeg* and the side dishes became a unique and value-added dish (Saputra et al., 2021). Thus, chicken is one of the popular main menus at various *Gudeg* outlets.

In a MSME of *Gudeg*, *Gudeg* Chicken is produced through a number of production process until the product is served to the consumer. *Gudeg* Chicken is produced in two separated kitchens in which the process starts from washing the chicken, cutting the chicken, squeezing the grated coconut, cooking and stirring the coconut milk, adding the spices and *areh,* stirring, placing the chicken into the distribution pan, placing the pans into van, distributing the products to restaurant, sorting the cooked products, heating the product, and distributing the product to service. Though it is still at the level of MSMEs, the process of producing *Gudeg* Chicken is not apart from the work accident. From the initial observation and historical data, it was found that it is potential for the workers to suffer an injury to their hand during the process of washing and cutting the chicken, there was a risk of back pain during the sorting process and suffer from the sore eyes caused by the smoke coming from cookstoves (Buruck et al., 2019; Lin et al., 2022).

In agricultural industry, the risk of work accidents has become a concern. The identification of work accidents aims to minimize the risk of workers in conducting the production

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activities. Even though the frequency of work accidents might still be low, the occupational safety and health system needs to be evaluated to achieve a zero accident rate (Bhastary and Suwardi, 2018), one of the ways is by conducting a research on the risks of work accidents in industry. To identify and analyze the work accidents, the Failure Mode And Effect Analysis (FMEA) method is used. Risk assessment can be analysed using the FMEA method, the objective of is to determine the level of risk of accidents in the workplace (Yanda et al., 2020); thus, it can be used as an early detection method for the analysis of occupational safety and health in industry. Recommendations for the improvement priorities were analyzed using Hazard Identification Risk Assessment and Risk Control (HIRARC) considering that this method can overcome and minimize the possibility of the risk of work accidents for workers (Ihsan et al., 2016).

Research related to work accidents in the production process of *Gudeg* chicken is still very rare; hence, it is deemed necessary to know the risks that might occur during the production process. This study, in turn, aims to: 1) analyze the types of work accidents existing in the production line of *Gudeg* Chicken to determine the improvement priorities based upon the risk of work accidents with the highest risk value; and 2) provide recommendations for improvements to this type of work accident.

## 2. MATERIAL AND METHODS

This research was conducted at one of the *Gudeg* MSMEs in Yogyakarta City, Special Region of Yogyakarta. The MSMEs produced *gudeg* with unripe jackfruit as the raw material, which is processed at around 200kg per day. In addition, the MSMEs processed 100 chickens per day, especially on holidays or peak season, it could be up to 300 kg per day. To process the food, the MSMEs needs 25 workers in the production area and the restaurant.

Work accidents were identified on the division of *Gudeg* Chicken production. The risk of work accidents in *Gudeg* chicken production division was determined based upon the results of observations in the production room and interviews with a number of operational managers. This study used FMEA as a methodology to evaluate any failures occurred in a system, design, process, or service (Stamatis, 2003). This research used FMEA process to identify any potential failure modes, potential effects of failure, potential causes, severity, occurrence, and detection. In FMEA, every possible failure occurred is assessed for making the handling priority (Andiyanto et al., 2017). The risk of failure mode in the FMEA method is estimated by calculating the Risk Priority Number (RPN).

Observations were made for a month in the production room of *Gudeg* chicken, including two *Gudeg* kitchens to determine the risk of work accidents occurred during the production process. The observation was focused on the *gudeg* chicken production. The procedure of processing the *gudeg* chicken can be shown in Figure 1.

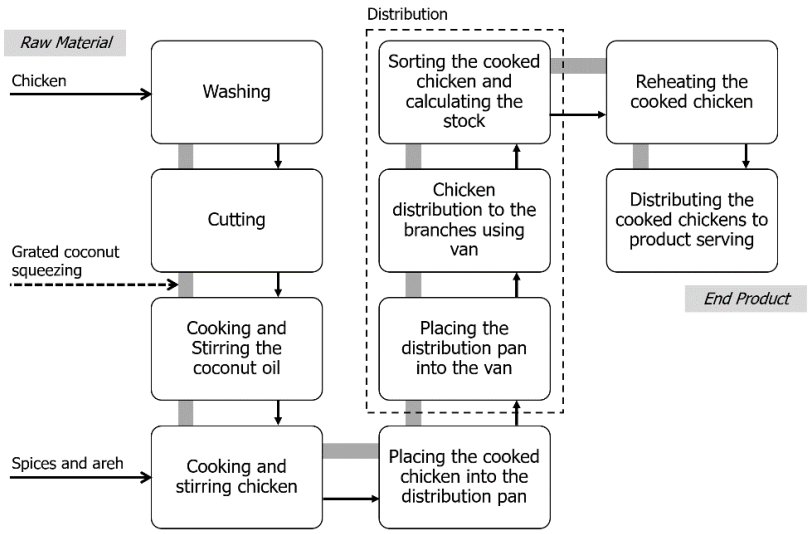


Figure 1. The Procedure of *Gudeg* Chicken Processing

In-depth interview was conducted to verify the results of observations and to obtain a list of risks of other work accidents that have been experienced by workers. The list of verified work accident risks was then made in the form of questionnaire that was used to find out the value of the severity, occurrence, and detection categories for each work accident risk. The verified questionnaire consisted of 20 questions for each category; in other words, there were 60 questions that must be filled in by each respondent. The questionnaires were distributed to six respondents consisting of operational manager, supervisor, quality control and production staff that have been selected by considering that they are the experts in this field and considered competent to provide an assessment in accordance with the condition in field.

The value of severity, occurrence, and detection obtained for each work accident risk was then averaged using the geometric mean, an average paying attention to all variables, not just a flat average and used to measure the rate of change of a variable according to time (Wahyono, 2010). The geometric mean of N units from the data population was calculated by Equation 1 (Perdana, 2018).

$$G = \sqrt[N]{X_1 . X_2 \dots X_n} \quad (1)$$

Description:
G = geometric mean
N = number of respondents
X = value of the $n^{th}$ respondent

The geometric mean value of severity, occurrence, and detection for each work accident risk was then used as data to calculate the RPN values. Equation 2 was used to calculate the RPN values.

$$RPN = S \; x \; O \; x \; D \quad (2)$$

Remarks:
S = Severity
O = Occurrence
D = Detection

The RPN values were analyzed using a pareto diagram to determine the highest risk of work accidents in production process of *Gudeg* chicken.The pareto diagram is a data histogram that sorts from the highest to the smallest frequency (Evan and Lindsay, 2007). The RPN values obtained will be sorted from the highest to the lowest RPN, indicating that the higher the RPN order, the higher the risk of work accidents. Furthermore, the risk of work accidents with the highest RPN value based on the results of the Pareto diagram, was given recommendations for improvement using the Hazard Identification Risk Assessment and Risk Control (HIRARC) related to efforts to prevent and control hazards in the Occupational Safety and Health (K3) management system (Desianna and Yushananta, 2020). Risk control in HIRARC consists of several levels, including elimination, substitution, engineering controls, administrative controls, and Personal Protective Equipment (PPE).

## 3. RESULTS AND DISCUSSION

### 3.1 Identification of Work Accident Risk

The risks of work accidents identified consisted of 20 types of work accidents originating from 12 stages of production and distribution in the kitchen of the *Gudeg* chicken production center. Table 1 shows the results of calculating the RPN values from the identified work accident risks. The risk of work accidents in the process of producing *Gudeg* chicken were found varied. These risks might come from the production process, workers, and environmental condition. The risks coming from the production process included the exposure to smoke coming from the chicken being cooked, splashed with hot spices, and flakes of firewood. Workers here became a source of risk, i.e. when sitting in an unergonomic position and during production activities carried out manually. As a consequence, it can pose a risk of work accidents (Table 1). Environmental condition also became a source of potential risk where there were many product wastes left in the production room such as coconut milk liquid and puddle in the production room. These risks

were identified as the potential to cause work accidents in the *Gudeg* chicken production process (Table 2).

Table 1. The Potential of Work Accident Risks on *Gudeg* Chicken Processing

| Code | Work Accident Risk | Process |
|---|---|---|
| FM 1 | Manual work of chicken-washing | Chicken washing |
| FM 2 | Heat source derived from the process of rolling the chicken intestines into the chicken gizzard | |
| FM 3 | Puddle in the cleaning area | |
| FM 4 | Chicken cutting is manually done using knife | Chicken cutting |
| FM 5 | Cocunut oil on the floor | Grated coconut squeezing |
| FM 6 | Squeezing is done manually | |
| FM 7 | A lot of smoke and hot temperature | Cooking and Stirring the coconut oil |
| FM 8 | Flakes of firewood | |
| FM 9 | Pouring the cocunut milk manually | |
| FM 10 | Splashes of hot seasoning | Adding the spices and *areh* |
| FM 11 | Manual stirring | |
| FM 12 | Manually inserting the chicken | |
| FM 13 | Stirring and changing the position of chicken manually | Cooking by stirring and changing the position of chicken |
| FM 14 | Heat and smoke from the freshly cooked chicken | Placing the cooked chicken into the distribution pan |
| FM 15 | Lifting the pan manually | Placing the distribution pan into the van |
| FM 16 | Uncertain and inadequate traffic condition (traffic jam or bad weather) | Chicken distribution to the branches using van |

| Code | Work Accident Risk | Process |
|---|---|---|
| FM 17 | Unergonomic sitting position | Sorting the cooked chicken and calculating the stock |
| FM 18 | Hot temperature in certain condition | Reheating the cooked chicken |
| FM 19 | Manually moving the container of stocked cooked chickens | Distributing the cooked chickens to product serving |
| FM 20 | The container is in hot condition | |

Table 2. Results of the Calculation of RPN Value

| Code | Potential Effect | S | Potential Causes | O | Process Controls | D | RPN |
|---|---|---|---|---|---|---|---|
| FM 1 | Injuring the labor's arm | 2.33 | Chicken giblets that were difficult to wash out with the tools | 1.85 | PPE was available, such as gloves | 5.72 | 24.64 |
| FM 2 | Heat and burning sensation on labor's arm | 5.31 | Contents of liver and chicken's intestines | 5.48 | PPE was available, such as gloves | 4.88 | 142.01 |
| FM 3 | Labors may slip and fall on the ground | 1.82 | Congestion in the drains due to the usage of non-production standard waterway system | 2.15 | The availability of drainage channel with regular maintenance | 7.48 | 29.3 |
| FM 4 | Injuring the labor's arm | 6.60 | Lack of specialised tools and mats chicken cutter | 5.16 | The availability of a spesific area for cutting and the availability of PPE, such as gloves | 3.96 | 134.6 |
| FM 5 | Labors may slip and fall on the ground | 1.59 | Coconut milk spillage | 2.00 | Regular cleaning | 8.16 | 25.91 |
| FM 6 | Injuring the labor's arm | 1.70 | Lack of coconut squeezer | 2.70 | Safety stock for coconut milk | 7.42 | 33.97 |
| FM 7 | Stinging eyes of the labor and discomfort in work | 5.90 | Air circulation is limited | 4.74 | Regular building maintenance to reduce heat absorption on the production area | 3.68 | 102.95 |

| Code | Potential Effect | S | Potential Causes | O | Process Controls | D | RPN |
|---|---|---|---|---|---|---|---|
| FM 8 | Injuring the labor's hand | 3.73 | Firewood had a hard and rough texture | 4.06 | Cloth usage to put the wood | 5.79 | 87.84 |
| FM 9 | Injuring the labor's arm | 2.62 | Lack of specialised tools to pour the coconut milk into the pot | 2.59 | PPE was available, such as gloves | 6.78 | 45.94 |
| FM 10 | Mild blistering on the labor's body | 3.67 | The procedure was done manually without tools | 3.24 | The availability of pan lid | 7.44 | 88.3 |
| FM 11 | Injuring the labor's arm and causing a backpain | 4.60 | No stirring machine due to excessive quantity of mixed ingredients and thick texture | 3.66 | Stirring was regularly carried out and using multiple pans | 4.02 | 67.58 |
| FM 12 | Injuring the labor's arm | 3.87 | The chicken had to be put into the pot one by one and in the order of cooking process | 2.71 | PPE was available, such as gloves | 6.34 | 66.63 |
| FM 13 | Pain in the arms, back, and labor's legs | 4.48 | The position of the pot was above the worker's waist, the quantity of cooking was large, and it had to be done regularly to maintain the quality | 5.97 | The availability of chairs and footrests | 4.84 | 129.44 |
| FM 14 | Stinging eyes of the labor | 5.58 | Material transfer should be done immediately after ripening to maintain quality | 4.14 | PPE was available, such as gloves | 5.37 | 124.13 |
| FM 15 | Pain in the waist, arms, and labor's legs | 6.65 | Lack of tools to transfer the pan to the box car | 2.14 | Short distance from the kitchen to the box car parking area | 6.76 | 96.16 |
| FM 16 | Fatigue of the driver | 3.23 | Long distribution distances and divided into several branches | 1.70 | Rest period for every branch | 6.56 | 35.95 |
| FM 17 | Pain in the labor's waist | 7.80 | The basin position was lower than the labor and the process was carried out for a long time | 6.16 | The availability of spacious sortation area | 3.36 | 161.43 |

| Code | Potential Effect | S | Potential Causes | O | Process Controls | D | RPN |
|---|---|---|---|---|---|---|---|
| FM 18 | Discomfort in work | 5.03 | Hot weather due to the use of galvalume roof | 4.30 | Multiple vents and fans | 5.16 | 111.57 |
| FM 19 | Injuring the labor's arm and causing a backpain | 4.60 | There was a ladder barrier that prevented the trolley from delivering the chicken stock to the serving area. | 3.14 | The availability of trolleys | 7.27 | 105.05 |
| FM 20 | Stinging and burning sensation on labor's arm | 4.60 | Basin material made of aluminium or stainless steel which were conductors | 3.38 | Cloth usage when transferring basin | 7.63 | 118.72 |

S = Severity; O = Occurrence; D = Detection

### 3.2 Improvement Priority

The analysis of improvement priority was done by processing the data using the Pareto diagram orderly indicating the level of improvement prioroties. In making the pareto diagram, it required the data of the work accident risks, the RPN values, RPN percentage values, and the cummulative percentage values of RPN. Figure 2 shows the work accident risks in the process of producing the *Gudeg* chicken sequentially.

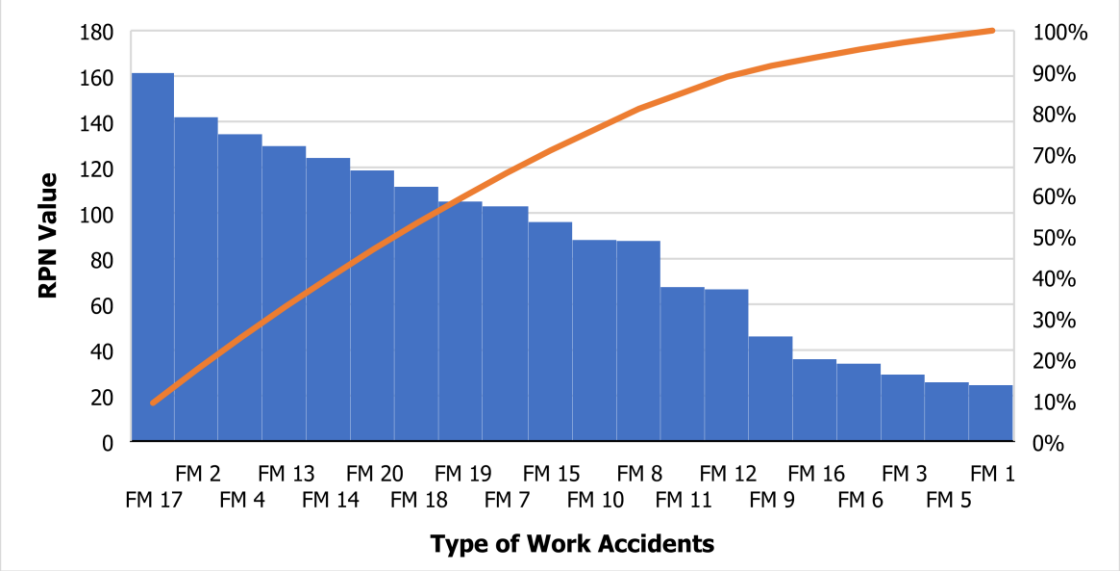


Figure 2. Pareto Diagram of Work Accident Risk in the *Gudeg* Chicken Production Process

As shown in the Pareto diagram, it was found that the types of work accidents were based on the level of risk from the largest level, i.e. the risk of work accidents with code of FM 17 or unergonomic sitting position in the process of sorting and calculating the stock of cooked *Gudeg* chicken. At the risk of work accidents with code of FM 17, the highest RPN value was 161.43 or 9.32% of the total RPN obtained. According to Knowlson (2022), the Pareto principle states that 80% of output comes from 20% of input, meaning that FM 17 can be the main cause of the risk of work accidents in the *gudeg* chicken production process. Working posture that is not in normal condition is the one needs to be a concern. Figure 3 shows the posture of worker in the sorting the cooked *Gudeg* chicken.

FM 17 had a severity value of 7.8 indicating that the work accident totally disrupted the work of the system. The sitting position of workers in the process of sorting and calculating the cooked *Gudeg* chicken stock was seen unergonomic since the chairs used were found higher than the sorting table. This then made the working position in a hunched state or even the worker must stand during working hours and this caused the backpain for the worker. This is consistent with research on ergonomic sitting posture stating that the most contributing factor to low back pain is an unfavorable position during activities. This causes disturbances in the musculoskeletal system and puts considerable pressure on the intervertebral discs; hence, it can cause lower back pain and in the long term it also can cause hunchback in the body (Wahyuni et al., 2020).

Figure 3. The posture of the worker in sorting the cooked *Gudeg* chicken

The occurrence value obtained was 6.16 indicating that the risk of this work accident had quite high probability of work accident occurrence with an occurrence rate of 1 time occurreed within 3 to 4 days. The high rate of occurrence is related to the the process carried out every day and for a long time.

The detection value obtained was 3.36 indicating that the control had a significant effect where the detection had a quite high probability to detect the type and cause of work accidents. The control for this work accident refers to the availability of a large work area enabling the workers to adjust their work position to get more comfortable working condition. However, this area was found not properly utilized by workers and there were no work facilities such as ergonomic desks and chairs. This control is carried out to create an ergonomic sitting posture while working where an ergonomic posture can reduce the work of the extensor muscles to fight against the load transmitted to the spine. By so doing, the possibility of spasm or strain on these muscles can be prevented (Wahyuni et al., 2020), including at the waist of the workers.

### 3.3 Improvement Recommendation

Based on the pareto diagram, it was found that the type of work accident with the highest value of RPN in the chicken production and distribution process that needs to be prioritized for improvement was FM 17 (unergonomic sitting position) with an RPN value of 161.43. The recommendation for improvement was analyzed using HIRARC to determine the control measures purposely to minimize the risk level and to prevent any work accidents (Urrohmah and Riandadari, 2019). Figure 4 shows risk control and recommendations using HIRARC.

The potential risks based on the results of existing hazard identification indicated that the type of work accident in an unergonomic sitting position was included in the high risk rating, meaning that senior management must pay more attention. The determination of the risk level based on the severity of this risk was at level 3 (moderate) because workers needed a medical treatment, causing the loss of working hours of more than 24 hours, and high financial losses and the likelihood of this risk was at level B (Likely) in view of the possibility of frequent occurrence within a week. The risk control hierarchy is byb using PPE in the form of gloves. Administrative control refers to the provision of SOPs related to the work environment allowed to carry out production processes and safety induction, making work schedules adjusted to workload, and monitoring the work environment on a

regular basis. Engineering control refers to the modification of the table used to make it higher than the chair or the modification of the chair to make it lower than the table. Also, it can be done through substitution by changing the sorting work area to another available area that has a good table and chair size for the work position. In this type of work accident, elimination cannot be done for risk control.

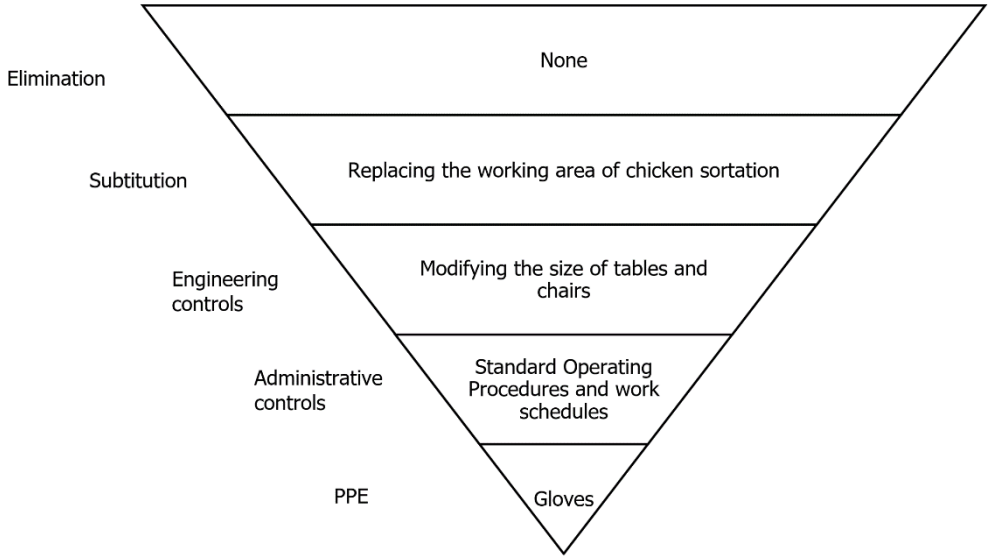


Figure 4. Recommendation of improvement based upon HIRARC

The risk control hierarchy for the risk of work accidents in the form of unergonomic work positions in the sorting process is by using PPE in the form of gloves, doing an administrative control by making SOPs related to the work environment to carry out production and safety induction processes and making work schedules adjusted to workload, engineering control by modifying the table used to make its height exceeding the chair or modifying the chair to make it lower than the table, substitution by changing the sorting work area to another available area that has a good size table and chair for the work position. However, in such work accident risk, elimimation cannot be done for the risk control.

## 4. CONCLUSIONS

*Gudeg* Chicken was prepared in two separate kitchens, along with the process initially from washing the chicken, cutting the chicken, squeezing the grated coconut, cooking and stirring the coconut milk, adding the spices and *areh,* stirring, and distributing the end product to the restaurant. The risk of work accidents in the *Gudeg* chicken production division as the priority for improvement was the risk of work accidents with the highest RPN value, i.e. FM 17 (an unergonomic sitting position in the process of sorting and calculating the stock of cooked *Gudeg* chickens). The RPN value for this work accident risk was 161.43 with a severity value of 7.8, an occurrence value of 6.16, and a detection value of 3.36. Recommendations for improvement that can be given are by providing PPE in the form of gloves, administrative control by making SOPs and making work schedules with the adjustment of workload, engineering control by modifying the height of workers' tables or chairs, shifting by changing the sorting work area, and here elimination of the production process for risk control cannot be done.

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