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Supplier Qualification Using FMEA in a Meat Company

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Abstract

The analysis of the processes between supplier and customer and the detection and handling of defects is based on objective, quantified criteria so that customer complaints can be handled as efficiently as possible, with the least possible inconvenience. One possible risk-management method is FMEA, or Failure Mode(s) and Effect(s) Analysis, which allows a team to anticipate and prevent failures from occurring anywhere. It is an analytical methodology to identify and check for potential problems when designing a product, service or process. It can be used to reduce the number of defective supplies and thus indirectly increase customer satisfaction (by more efficient purchasing, the price can be kept lower and the quality higher, and fewer customer complaints from end users can be expected). It was used in this study to assess the supplier quality of a Hungarian industrial company in the FMCG sector and to make tangible improvements in a short time to eliminate supplier defects.

Keywords

FMEA, supplier, food industry, classification, risk

1 Introduction

One of the critical elements of a company's operation is establishing and operating an appropriate quality management system. The value chains associated with companies' operations typically include manufacturing and service activities. The analysis of such production-service value chains requires a general process analysis, taking into account the specificities of production and services while maintaining appropriate quality (Kalló and Gerse-Krizsa, 2021). These systems are adapted to the specificities of the companies but are developed based on a set of requirements with standard guidelines (Könyves and Kalló, 2022). Digitalisation and Industry 4.0, which represent its peak in the manufacturing sector, are now permeating all economies in the world, linked to the development of appropriate quality assurance systems (Demeter et al., 2023). Implementing all this will be a crucial issue in its operation in the future (Kovari and Katona, 2023) An inescapable aspect of the operation of economic organisations and companies and of the quality assurance systems they use is sustainability, which can be used to create long-term value (Ogutu et al., 2023).

Failure Mode(s) and Effect(s) Analysis (FMEA) was developed in 1949 by the United States Air Force to analyse failure modes, possibilities and effects. It has become one of the most popular and well-known risk analysis methods (Koncz et al., 2021). As with many military processes and developments, FMEA has percolated into civil (non-combat) applications (Bényei et al., 2020). It was first used in the 1960s in civil aviation by the aerospace industry, and in the late 1970s, it was introduced in the automotive industry, all in response to increased safety standards and consumer demand (Sharma and Srivastava, 2018). Today, FMEA has been adopted in almost every industry, from healthcare to food and IT (Haddad, 2016), as it has become a systemically proven analysis method for investigating various processes thanks to continuous developments in risk analysis (Koncz et al., 2022).

2 Method

The procedure is an analytical methodology used to identify and check for potential problems when planning a product, service or process (Advanced Product Quality Planning (APQP)) (Szilágyi et al., 2014). The analysis aims to identify potential defects at the design stage. In practice, it is a system that includes the detectability of possible defects, the effects of defects and their causes, and suggestions for prevention. It can help set expectations when designing a new product or service.

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Although the system is time-consuming to implement, it saves time for users once implemented. It is based on an objective, quantified basis for analysing the processes between the supplier and the customer and identifying and handling defects so that customer complaints can be dealt with as efficiently as possible, with minimal inconvenience. The introduction of the FMEA method can reduce the number of faulty deliveries, thus indirectly increasing customer satisfaction (more efficient purchasing can keep prices lower and quality higher, and fewer customer complaints from end users can be expected) (Szilágyi et al., 2014). The FMEA system follows the steps defined by the acronym "DAMUK", see in Fig. 1.

2.1 Definition (D)

Define the categories of possible errors and the persons responsible for identifying them. In this step, the criteria set for the product or service must be listed and evaluated. The risk weighting of the different potential defects is also defined in Section 2.1 as follows: 0: no risk; 1: low risk; 3: some risk; 9: exceptionally high risk (Szilágyi et al., 2014).

2.2 Analysis (A)

In the analysis phase, we assess the potential and risks of the criteria's acceptability, verifiability. There are five steps to apply the FMEA:

- Structure analysis: analysis of system, subsystem and component; in this case, it can be understood in terms of the supply network, the specific supply and the product supplied.
- Functional analysis: analysis of the functions assigned to the structural elements and their interrelationships.
- Fault analysis: Analysis of the faults assigned to functions and their relationships.
- Analysis of measures: analysis of existing and planned measures.
- Optimisation.

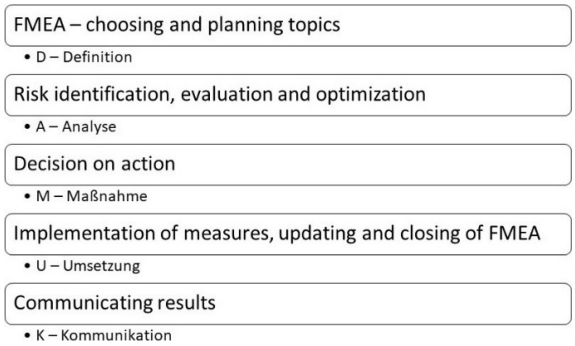

Fig. 1 Elements of the DAMUK model

A number derived from the product of three risk values, RPN (Risk Priority Number), is used for the assessment, which can be calculated according to relation (Eq. (1)):

$$\mathrm{RPN} = \mathrm{O} \times \mathrm{S} \times \mathrm{D}, \tag{1}$$

where:

- O: frequency of occurrence of the error;
- S: the severity of the impact of the failure;
- D: the probability of detecting the error.

The quantification of these risk factors will be explained later (Szilágyi et al., 2014).

2.3 Decision on the measures (M)

At this point, deciding on the possible measures and working out the necessary adaptations is necessary. It is essential to consider the cost implications of the measure, whether it is worth investing the resources required and whether the resource requirements of the measure are lower than the expected return on investment in resolving the failure (Szilágyi et al., 2014).

2.4 Implementation, realisation (U)

This phase involves the implementation and enforcement of the measures adopted and the evaluation of their effectiveness. It is not enough to implement the measures, their effectiveness must also be assessed, and an adjusted risk priority value must be calculated even if we expect the probability of failure to decrease. If this value falls to an acceptable level or below, the measure has been successful. If it remains above the acceptable level, further measures should be developed to reduce the risk of failure (Szilágyi et al., 2014).

2.5 Communication (K)

At this point, the supplier is also involved in the investigations. The aim should be to ensure that the actions result in a common knowledge base accessible to both parties and can improve the effectiveness of long-term cooperation (Szilágyi et al., 2014).

3 Analysis

3.1 Interpreting the risk factors

The risk factors were assessed from the point of view of the suppliers of a company operating in the electronics industry. The following main categories were identified:

- Quality problem;
- Delivery punctuality;

- Quantity discrepancy;
- Lack of certificate;
- Lack of supplier's declaration;
- Inadequate communication;
- Inflexibility.

3.1.1 Frequency of error scoring (O)

Table 1 summarises the probability of occurrence of the errors and their scores, which are interpreted as the number of times out of 10 deliveries the error occurs.

3.1.2 Scoring the severity of the error effect (S)

In Table 2, a classification of the impact of the defects on production and product safety has been made, taking into account whether the company's preventive measures can handle the defect or whether there is also an issue of production or processing safety. Defects that can be handled within the company also represent a loss to the enterprise but do not directly threaten production.

The interpretation of each aspect is as follows:

- No impact: the product can be used;
- Insignificant impact: work in progress (WIP) stocks cover any downtime caused by the defect;
- Moderate impact: production or use of stocks needs to be rescheduled;
- Severe impact: the product does not meet the requirements set for it, endangering production;
- No use: poses a food safety risk, the raw material must not be used in production, products must be removed from store shelves (if the raw material has been used in production), and a recall must be issued.

3.1.3 Scoring the detection of the error (D)

In Table 3, the scoring of the detectability of the errors is done.

3.2 Risk assessment and analysis

In order to quantify the risk factors, the criteria for each assessment category are always considered a failure. The O, S and D values are assigned to each aspect. The RPN is then calculated as the product of these. The value of the RPN can be between 1 and 1000, within which the values of the different risks are categorised. The categories are defined as follows:

- A: low risk hazard; tolerable risk: 1–49;
- B: moderate risk hazard: tolerable with limits: 50–99;
- C: risk value of concern: to be considered: 100–199;
- N: no risk or a risk that can only be taken with good reason: 200–1000.

Table 4 shows the score and RPN for each risk factor and that of the 12 hazards listed, 8, or exactly two-thirds, fall into category A.

Table 1 Frequency of occurrence/error scoring

Scores	Probability of errors occurring
1	Unique error
2–3	Rarely occurring error
4–6	Possible error
7–8	Common error
9	Particularly common occurrence
10	Failure cannot be avoided

Table 2 Scoring the severity of the error effect

Scores	Impact of the error on production
1	No impact
2–3	Insignificant impact
4–6	Moderately severe impact
7–8	Severe impact
9–10	Cannot be used

Table 3 Scoring the detection of the error

Scores	Detectability of occurrence
1–2	Safe (easy to detect)
3–4	High detectability
5–6	Moderate detectability
7–8	Low detectability
9	Dangerous
10	Hidden error

Table 4 Risk factors scoring and RPN values

Main categories	O	S	D	RPN
Quality problem				
Grafting/loss (kg)	3	1	1	3
Machining/human error (kg)	2	1	4	8
Organic foreign matter (piece)	6	8	9	432
Inorganic foreign matter (piece)	7	8	7	392
Defective packaging, roll, core heat (piece)	3	7	3	63
Microbiological/chemical (piece)	5	7	3	105
On time delivery				
Early/delayed delivery	2	5	2	20
Quantity difference				
Quantity ordered/received ratio	3	4	1	12
Other				
Certificate missing	3	1	2	6
Absence of supplier's declaration	4	1	2	8
Incorrect communication	3	1	4	12
Inflexibility	2	4	3	24

The criterion "Defective packaging, rolls, core heat (pieces)" is classified as "B", which represents 8.33% of the criteria. These hazards are acceptable within limits and regulations. The rules on packaging and wrapping allow for some discounts, with several options offered by the acceptable specifications. In the core temperature test, it can be used if the product meets the other parameters and the frozen (−18 °C) product is sent for thawing by production after receipt.

The risk "Microbiological/chemical (pcs)" was classified as "C", which also represents 8.33% of the risks assessed. For the Microbiological and Chemical results, margins of error are also given for each parameter. For specific microbiological results, the risk is low if the raw material is incorporated into a heat-treated product. For example, in the case of chemical variations, high calcium in chicken MDM can be reduced by adding chicken breast, and low fat in turkey breast can be increased by adding turkey skin fat.

Risks caused by organic and inorganic contaminants are classified as 'N', accounting for 16.67 % of all test criteria. The very high values are due to the frequency of occurrence and the difficulty of detection. The risk is further increased by the fact that the end user may not detect a packaging defect, but an undetected piece of plastic in the product will be noticed by the end user, which may lead to customer dissatisfaction and complaints.

The different aspects were then ranked using the Pareto principle, as shown in Fig. 2.

Fig. 2 shows that organic and inorganic contaminants are responsible for 39.82% and 36.13% of the risk values, respectively. This means that 75.95% of the total risk values are due to risks of foreign matter origin.

4 Results and discussion

Using the method presented in Section 2, the FMEA analysis was carried out as follows.

4.1 Presentation of the DAMUK steps

4.1.1 Definition (D)

Based on Table 4 and Fig. 2, the two risk factors requiring immediate intervention were defined as follows:

- Organic foreign matter (RPN = 432);
- Inorganic foreign matter (RPN = 392).

In light of the results, the Quality Assurance Department was informed and started working on action plans. The Meat Procurement Department will assist in disseminating, implementing and coordinating with the supplier.

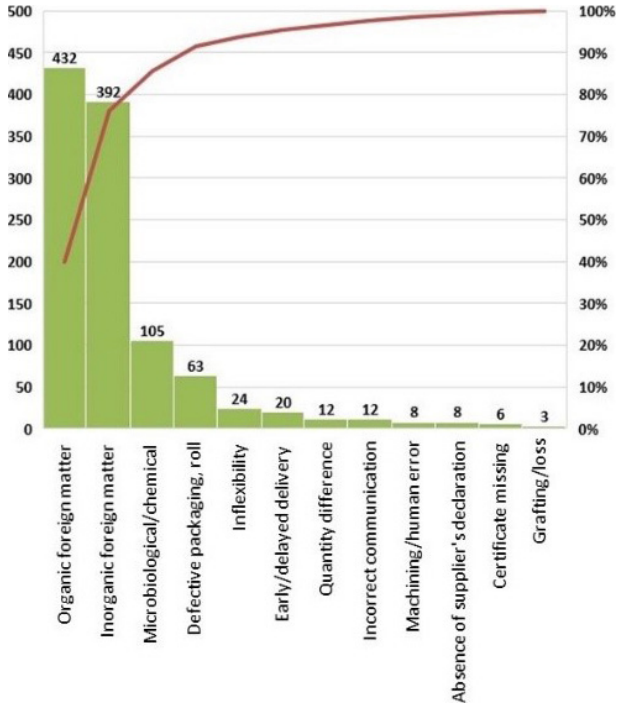

Fig. 2 Grouping of RPN value of defects according to the Pareto principle

4.1.2 Analysis (A)

In Table 4, the results of the entire year supplier assessment for 2021 have been developed and used as the basis for setting the targets and expected return on investment.

The objective is to reduce the value of risk factors that are not accepted or are only risk-rated "N" to 199 or below the risk of concern "C" in the period through the first quarter of 2022. It is important to note here that the ideal would be to achieve an A rating, but in determining the effectiveness of the process, measurable and predictable clear targets should be used with realistic achievability.

Achieving the target value would result in 53.94% for organic impurities and 49.23% for inorganic impurities. A reclassification from total "N" to "C" is expected to result in a 51.70% result. The evaluation of the results will be finalized after the supplier evaluation for the first quarter of 2022.

4.1.3 Decision on the measures (M)

The Quality Assurance Department develops the measures. For different suppliers, specific plans will be developed, such as company visits and coordination between the supplier and the company's quality auditors and the people involved in the project. Within the company, there is the possibility of tightening up the acceptance of goods, hiring an employee responsible for controlling foreign materials or using various detection devices (metal detectors, X-ray detectors). However, it is essential to note that none

of these methods can detect plastic or metal particles less than 5 mm in diameter without error and cannot be used for certain forms of organic contamination (animal remains, faeces, small insect carcasses). The return on investment should be planned with this in mind. The ideal case is to identify and address the critical points at the supplier where the contaminant may be introduced into the product before delivery so that the supplier's improvement and the quality of the purchased raw material can be corrected.

4.1.4 Realisation, implementation (U)

The various measures were agreed and implemented from January to March 2022, and the results will be evaluated.

4.1.5 Communication (K)

The results of the evaluations were communicated to the suppliers by the Quality Assurance Department's FMEA project officer in accordance with the actions taken against the supplier.

4.2 Comparison of FMEA before and after development

After the first quarterly supplier assessment in 2022, the RPN values will be calculated again in April 2022, broken down by categories based on the same criteria. All hazards will be reviewed again, as the process aims to reduce the risk of organic and inorganic contaminants in products, but the evolution of other hazards will also be reviewed. Table 5 shows the scores following the supply assessment.

Table 5 RPN point values after application of FMEA

Main categories	O	S	D	RPN
Quality problem				
Grafting/loss (kg)	3	1	1	3
Machining/human error (kg)	2	1	4	8
Organic foreign matter (piece)	3	8	7	168
Inorganic foreign matter (piece)	4	8	5	160
Defective packaging, roll, core heat (piece)	4	7	3	84
Microbiological/chemical (piece)	4	7	3	84
On time delivery				
Early/delayed delivery	3	6	2	36
Quantity difference				
Quantity ordered/received ratio	3	4	1	12
Other				
Certificate missing	3	1	2	6
Absence of supplier’s declaration	4	1	2	8
Incorrect communication	3	1	4	12
Inflexibility	2	4	3	24

It is observed that the detectability of organic contaminants has improved. This result is due to the measure to add a staff member dedicated exclusively to the detection of foreign substances to the existing staff at the reception, so that, thanks to his training in this area and the fact that this is his only task, he can concentrate much more on the detection of foreign organic substances.

Unfortunately, due to logistical uncertainties and panic buying (pandemic situation) during the period, the number of late deliveries and thus the level of risks affecting production has increased, but it is still classified as 'A'.

The typical result of the company visits, the discussions and the identification and management of critical points is that the proportion of dangerous supplies is lower in terms of foreign substances and the detection of microbiological hazards than in 2022.

However, the most significant progress was achieved in the field of contaminants, with a score of 168 points for organic contaminants and 160 points for inorganic contaminants compared to the upper limit of 199 for the C classification. This means that the measures met the expected level and exceeded it.

For organic xenobiotics, the result is 61.11%, which is 7.17% above the expected target. For inorganic contaminants, the risk reduction rate is 59.18%, an improvement of 7.48% over the target. The overall results were 60.19%, 8.49% above expectations.

Fig. 3 again shows the risk factors ranked according to the Pareto principle based on their RPN values.

In terms of ratings, 8 risk categories still have an "A" rating, so there has been no change in this respect.

Two categories achieved a "B" rating: there was no change in the rating for insufficient packaging, rolls and core temperatures, but the market conditions increased the number of frequencies, resulting in a 33.3% increase in the risk value. The number of microbiological variations has decreased due to the measures taken and can therefore be classified as a moderate risk hazard. This represents an improvement of 20% for microbiological hazards compared to the full-year risk value for 2021.

A "C" classification was achieved for organic and inorganic contaminants.

No risk factor was classified under the category "N", which represents a risk value that cannot be used or can only be used with good reason, due to the application of the FMEA analysis and the DAMUK method, in particular the measures.

5 Summary

In our research, we have demonstrated the value of using FMEA after quarterly and annual supplier assessments. It is recommended to follow the Pareto principle for risk factors, because the higher the value of a risk factor, the higher the probability that the company will incur a loss in line with production. Nevertheless, it is worthwhile to keep a constant watch on the market and react to its changes, as risk factors can be significantly influenced by the purchase of a lower consumption, higher volume and lower price of poultry material, where any of the risk factors increases the frequency of occurrence.

It may also be useful to consider the risks of foreign material by feedstock, as this can narrow down the cross-section of which feedstocks are typically at risk and thus determine the riskiness of certain products. It is also recommended to carry out an FMEA and identify the risk factors for each supplier individually, so that the risk scores for that supplier can be used as a measurable, objective factor for the purchaser in subsequent competitive tenders.

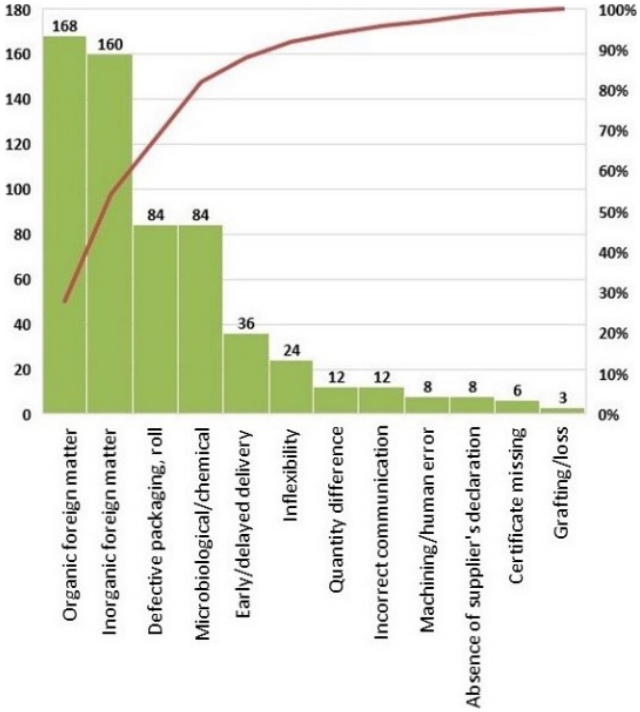

Fig. 3 Grouping of RPN values according to the Pareto principle after FMEA

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