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ASSESSMENT OF SUPPLIERS IN FOOD BUSINESS: IS THERE A WAY TO ESTIMATE THE RISK?

S u m m a r y

The objective of the study was to develop an easy-to-apply method for assessing the supplier-linked risk in the food business. The method as suggested in the study makes it possible to calculate, using simple mathematical tools, a level of risk involved in the cooperation with a particular supplier. The risk assessment is based on six criteria set for every supplier: type of commodities or products provided by the supplier; period of the cooperation with the supplier; systems applied by the supplier to assure quality and safety; past performance of the suppliers with respect to delayed deliveries, cancelled deliveries, and claimed deliveries owing to improper quality of raw materials. The method developed was validated in three companies: meat plant, dairy plant, and catering facility. A simple method was proposed to assess what risk a particular supplier could bring on the quality and safety of finished food product. This risk assessment method can be applied in different food businesses. The greatest benefit of the method developed consists in its ease of use and functionality. The suggested method can be used by small companies and it does not require any complicated calculations or advanced statistical techniques. The method can be very useful for enterprises; however, it has certain limitations such as knowledge and awareness of its users.

Key words: supplier, risk, risk assessment, food safety, food quality, hazard

Introduction

Risk assessment is a well-established concept in the literature, legal codes, and in the quality management standards. However, there are only a few practical examples

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addressing risk assessment at the level of food business operators [10, 26] and in other areas. Based on Regulation (EC) No. 178/2002 [22], the European Food Safety Authority (EFSA) assesses food and feed safety risk on a scientific basis. Therefore, a question arises as to how the representatives of catering businesses and food producers may adopt a similar approach to identify and mitigate the risk associated with their activities.

Despite many food safety campaigns, educational, informative, audit, and certification activities, food poisoning is still a major cause of diseases [9]. Maintaining food safety is connected with understanding the safety risks relevant to various food products and with recognizing the importance of risk mitigation [21]. Risk assessment by EFSA and by other national and international authorities should be based on scientific evidence and should be implemented in an objective, independent and clear way [22]. It focuses on the food safety and, thereby, it helps food business operators analyze the hazards associated with their products and develop systems (preventative measures, including HACCP) to control those hazards. Food business operators are required to carry out a hazard analysis, but various data suggest the adoption of the risk assessment approach by the food industry can perform a very useful function supporting the company's performance and preventing food-borne diseases. The research carried out by Trafiałek and Przybylski [26] showed how risk assessment could be used to determine the cancer risk resulting from the intake of heterocyclic amines while consuming heat-treated pork meat. In their study, Trafiałek and Pawłowska [25] proved the importance of risk assessment in determining the odds of mistakes committed by employees with insufficient training, and Kołożyn-Krajewska et al. [10] assessed the risk of using probiotics in meat products.

ISO 9004:2009 recommends that risk should be identified and strategies developed to diminish it in order to achieve a long term success in an organization. ISO 9004 emphasises the importance of proven evidence when assessing suppliers, resources, and decision making process.

The suppliers play a significant role in food industry sectors. The quality of the final product is determined by many factors and one of the most important is the quality of raw materials used and the qualifications of suppliers. According to IFS or ISO 22000, each organization should apply procedures to identify, choose and evaluate suppliers in order to guarantee the required quality of the products to be delivered or of raw materials that should meet the expectations of a given organization. Therefore, it is essential to effectively monitor the cooperation with the supplier as well as the quality of the delivered raw materials. Nowadays, food producers and food industry entrepreneurs have many food standards and specifications they must refer to, but they often lack the knowledge to assess the suppliers and to support their development [28]. Those authors suggest using third parties audits and relying on their results. However,

single audits of suppliers are not reliable enough as the mistakes may not be identified. In order to carry out risk assessment on suppliers, auditors need particular knowledge and skills that are different to those needed in the process of certification, where the only aspect checked is whether or not the supplier has an acceptable safety and quality management in place. Powell et al. [20] say that audits and inspections are insufficient to ensure food safety, and stress the importance of a "food safety culture" and risk-based verification steps. Food safety is directly connected with consumer health.

Access to safe and high-quality raw materials plays an important role in producing safe food and, from the economic point of view, it is directly connected with the reliability of suppliers. Linthorst and Telgen [15] suggest that one of the most effective strategies for overcoming the risk of delayed deliveries is the use of many different suppliers. The choice of suppliers is a very important management process in the food business and it requires well-structured operational procedures. Generally, there are two methods of choosing suppliers: "single sourcing", i.e. one supplier can meet all the needs of the purchaser, and "multiple sourcing" where in order to decrease the risk of non-availability of raw materials, the purchaser buys raw materials from a few suppliers [1]. Cooperating with suitable suppliers decreases the costs and improves competitiveness [17]; thus, the purchase strategy is a critical activity for a company [4].

This paper presents the assessment of suppliers to food processors, who use several suppliers ("multiple sourcing"). In contrast to the study carried by Meena et al. [17], in this study a simple method of assessing suppliers is suggested that does not require advanced mathematical calculations.

The objective of the study was to develop a method of assessing the risk associated with the performance of suppliers and to verify its applicability to some food companies.

Materials and methods

The risk associated with the supplier performance was assessed based on the quality and safety of food products-related criteria. The criteria were obtained from the literature and presented in the chapter presenting the results and discussion. The method of risk assessment was designed, tested, and validated according to the procedure scheme as presented in Fig. 1.

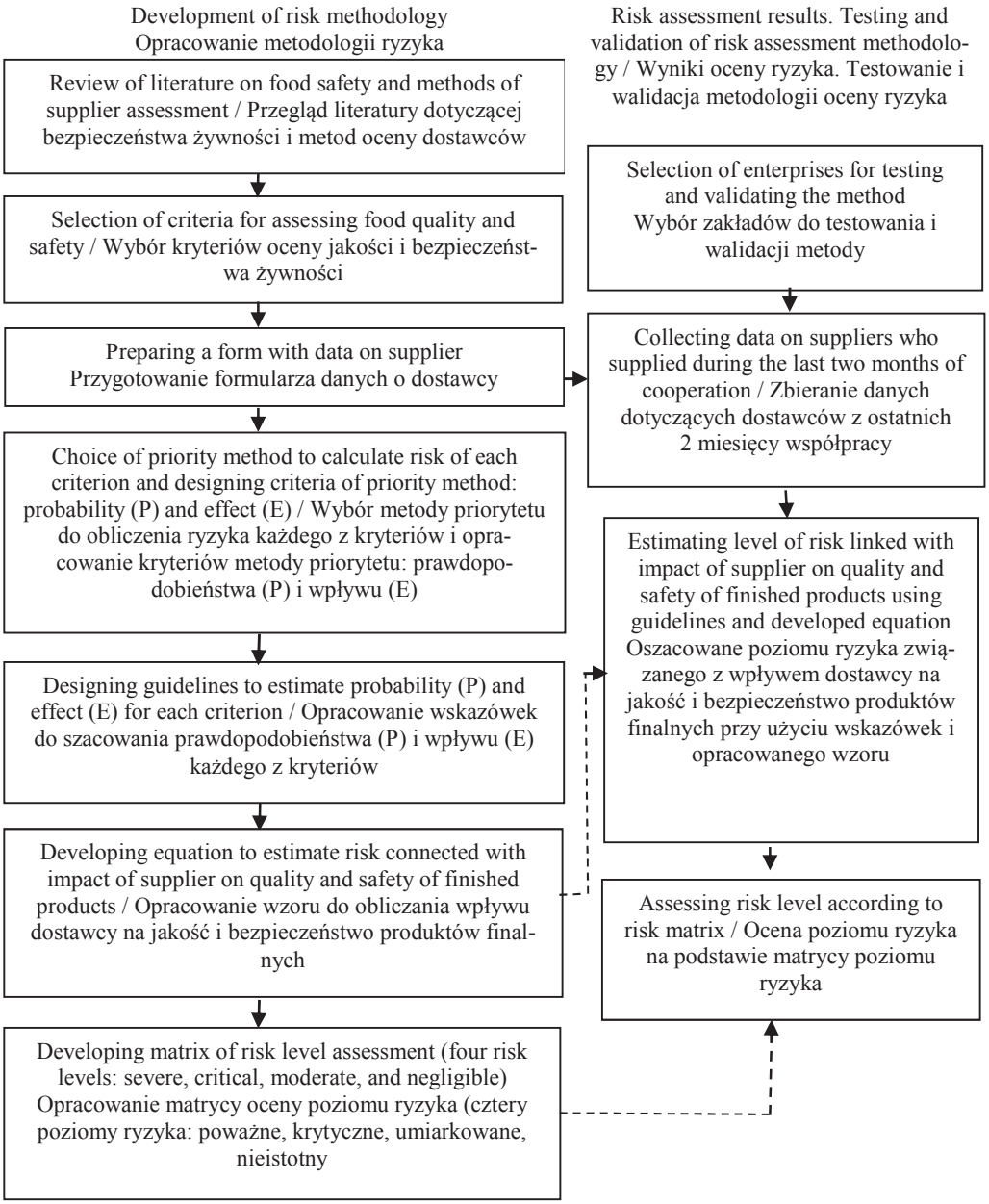

Fig. 1. Risk assessment flowchart
Rys. 1. Schemat postępowania przy ocenie ryzyka

The proposed methodology for risk assessment was applied in three companies and its applicability was tested therein. One of the companies was a medium size (50-249 employees) meat producing company based in Norway; the second one was a big (above 250 employees) dairy plant in Poland; the third one was a small Polish catering business. The factor to determine, which companies should be selected, was the willingness of their managements to cooperate with the scientists and to give researchers access to all the data on their suppliers. In order to assess the risk related to the cooperation with a particular supplier, the companies were asked to collect data on six suppliers so that the motives for their choice of a supplier became evident [8]. Those facts were compiled using standard forms (Tab. 1); the companies were asked to complete them.

Table 1. Form containing data on supplier
Tabela 1. Formularz zawierający dane o dostawcy

Supplier No. / Dostawca nr ……	Supplied material Dostarczany surowiec ……
Category of raw material supplied by supplier Kategoria surowca dostawcy: □ raw material directly involved in production surowiec bezpośrednio związany z produkcją □ raw material indirectly involved in production surowiec pośrednio związany produkcją □ raw materials intended to come into contact with food surowiec do kontaktu z żywnością □ general raw materials / surowiec ogólny	Years of cooperation with supplier Lata współpracy z dostawcą □ 0-2 □ 2-4 □ 4-6 □ 6-8 □ above 8 / powyżej 8
Total of all supplies from one supplier within last two months / Suma wszystkich dostaw od jednego dostawcy w ciągu ostatnich dwóch miesięcy……	
Food safety and quality assurance system and quality management system Systemy zapewnienia bezpieczeństwa i jakości żywności oraz zarządzania jakością □ GMP/GHP, HACCP implemented / Wdrożone zasady GMP/GHP, HACCP □ ISO 22000 system implemented / Wdrożony system ISO serii 22000 □ Management systems implemented / Wdrożone systemy zarządzania	
Number of delayed deliveries from one supplier within two months / Liczba opóźnionych dostaw od jednego dostawcy w ciągu dwóch miesięcy……	
Number of orders returned to one supplier within two months / Liczba zamowień zwróconych do dostawcy w ciągu dwóch miesięcy …….	
Number of claimed orders/deliveries from one supplier within two months / Liczba zamówień zareklamowanych od jednego dostawcy w ciągu dwóch miesięcy ……	

Results and discussion

The smooth functioning of a company and the safety and quality of its products is substantially related to the selected suppliers. Berger et al. [3] studied the risk connected with the activity of suppliers that related to mistakes made by them. Their research

showed that the mistakes made by suppliers could have significant consequences for the enterprise. The quantitative model compared the costs of running a company and the costs caused by mistakes on the part of the suppliers. The results proved that the running costs increased when the number of suppliers increased although the risk of failure in a particular purchasing company decreased where there were more suppliers. [4]. The authors concluded that the cooperation with only one supplier put a company at risk since the production would have to stop due to lack of raw material, whereas cooperating with more suppliers increased the initial and running costs because of the need to manage a larger number of suppliers.

The proposed method of risk assessment is based on estimating 6 criteria related to the performance of a particular supplier and relevant to the quality and safety of products. The criteria were: type of the raw material provided by the supplier; number of years of cooperation with a particular supplier; delayed deliveries; cancelled deliveries; complained deliveries; systems used to assure and manage food quality and safety. In order to get a numerical value of the risk, the commonly employed priority method was applied using the estimated values of probability (P) and effect (E) in the following equation [16]:

$$R_C = P \times E \quad (1)$$

where, as for the criterion C:
R_c – are scores to rank the risk of this one criterion, which means that failures at the supplier level adversely affect the safety and quality of the finished products;
P – are scores to rank the probability that such failures occur at the supplier level;
E – quantifies to what extent those failures affect the quality and safety of finished products.

Probability (P) and effect (E) are determined on the basis of subjective experimental data or archive data from previous period using a 5-level scale (from 1 to 5). The proposed scores for ranking the probability and effects are shown in Tab. 2 and 3.

Tab. 4 shows the guidelines to estimate the probability and the effect.

The overall R risk for product quality and safety as affected by the performance at the supplier level can be calculated by totalling up the risk of each criterion using the following equation:

$$R = \sum_{n=1}^{n=6} R_C \quad (2)$$

where:
R_C is risk of one criterion;
R is the level of the supplier-related risk;
n is the number of suppliers.

Table 2. Levels of probability of adverse effect of criterion on quality and safety of finished products
Tabela 2. Poziom prawdopodobieństwa niekorzystnego wpływu kryteriów na jakość i bezpieczeństwo produktów gotowych

(P) Level of probability Poziom prawdopodobieństwa (P)	Description / Opis
1	Very low, almost impossible / Bardzo małe, prawie niemożliwe
2	Low, insignificant / Małe, nieistotne
3	Mild, medium / Łagodne, średnie
4	High, significant / Duże, istotne
5	Very high, serious / Bardzo duże, poważne

Table 3. Levels of impact of criteria on quality and safety of final products
Tabela 3. Poziom wpływu kryteriów na jakość i bezpieczeństwo produktów gotowych

Levels of impact (E) Poziom wpływu (E)	Impact effects of one criterion / Efekty wpływu jednego kryterium
1	Insignificant: no deterioration in quality and safety of final products, unimportant criterion / Nieistotne: brak pogorszenia jakości i bezpieczeństwa produktów finalnych, kryterium nieważne
2	Noticeable negative impact on quality and safety of products Zauważalny negatywny wpływ na jakość i bezpieczeństwo produktów
3	Significant, possible negative financial consequences, increase in number of claims owing to lack of quality and damage to health of consumers / Istotne możliwe negatywne konsekwencje finansowe, wzrost liczby reklamacji z powodu braku jakości i uszczerbku zdrowia konsumentów
4	Serious loss of quality and safety, financial consequences Poważna utrata jakości i bezpieczeństwa, konsekwencje finansowe
5	Very serious alert notification to be sent to RASFF, death or serious illness of consumer, compensation for consumer, loss of liquidity of company / Bardzo poważne zgłoszenie do system RASFF, śmierć lub poważne zachorowanie klienta, odszkodowanie dla klienta, utrata płynnosci finansowej firmy

While using the suggested method, the overall risk was assessed on the basis of the matrix of risk assessment and categorized into four risk levels: severe, critical, moderate, and negligible (Fig. 2).

Table 4. Guidelines to estimate probability and effect of criteria on quality and safety of final products
Tabela 4. Wytyczne do określania prawdopodobieństwa i wpływu kryteriów na jakość i bezpieczeństwo produktów końcowych

Criterion / Kryterium	Description / Opis	P	E	R_C
Category of supplier Kategoria dostawcy	General materials / Surowce ogólne	1	1	1
	Materials in contact with foods Materiały do kontaktu z żywnością	2	2	4
	Indirect raw materials involved in production / Surowce pośrednio związane z produkcją	4	4	16
	Direct raw materials involved in production / Surowce bezpośrednio związane z produkcją	5	5	25
Number of years of cooperation with the supplier Liczba lat współpracy z dostawcą	Above 6 years / Powyżej 6 lat	1	1	1
	4 - 5 years / 4 - 5 lat	2	1	2
	1.5 - 3 years / 1,5 - 3 lat	3	1	3
	0.5 - 1 years / 0,5 - 1 roku	4	1	4
	Up to 0.5 year / Do 0,5 roku	5	2	10
Delayed deliveries (number of delayed deliveries from one supplier / total of all supplies from supplier × 100 % Dostawy opóźnione (liczba dostaw opóźnionych od jednego dostawcy / suma wszystkich dostaw od dostawcy) × 100 %	0 - 2 %	1	3	3
	2 - 10 %	2	3	6
	10 - 30 %	3	3	9
	30 - 50 %	4	3	12
	50 - 100 %	5	3	15
Outstanding deliveries (number of outstanding orders not delivered by one supplier / total of all supplies from supplier) × 100 % Dostawy niezrealizowane (liczna zamówień niedostarczonych przez jednego dostawcę / suma wszystkich dostaw od dostawcy) × 100 %	0 - 2 %	1	2	2
	2 - 10 %	2	2	4
	10 - 30 %	3	3	9
	30 - 50%	4	3	12
	50 - 100 %	5	3	15
Complained deliveries (number of complained from one supplier / total of all complained supplies from supplier) × 100 % Dostawy zareklamowane (liczba zareklamowanych dostaw od dostawcy / suma wszystkich dostaw od dostawcy) × 100 %	0 - 5 %	1	5	5
	5 - 10 %	2	5	10
	10 - 20 %	3	5	15
	20 - 50 %	4	5	20
	50 - 100 %	5	5	25
Foods safety and quality assurance systems and management systems Systemy zapewnienia bezpieczeństwa i jakości oraz systemy zarządzania	Lack of GMP/GHP, HACCP Brak GMP/GHP, HACCP	5	5	25
	Lack of ISO 22000 / Brak ISO 22000	2	2	4
	Lack of management systems Brak systemów zarządzania	1	1	1
	Implemented systems according to the forms filled by supplier Wdrożone systemy zgodnie z ankietą wypełnioną przez dostawcę	0	0	0

Value of calculated risk Wartość obliczonego ryzyka (R_{min} = 10, R_{max} = 115)	75 - 115				
	56 - 75				
	41 - 55				
	10 - 40				
		1	2	3	4
		Negligible Nieistotny	Moderate Umiarkowane	Critical Krytyczne	Severe Poważne
		Risk level / Poziom ryzyka			

Fig. 2. Risk estimation matrix
Rys. 2. Matryca szacowania ryzyka

Depending on the overall risk, certain actions towards the suppliers were recommended. In the case of a severe risk, it is necessary to warn the supplier in writing that the cooperation with him is to be terminated and the negotiations with a new supplier should be initiated. It could also result in immediate termination of the agreement with a particular supplier and in replacing the suppliers. When a critical risk is reported, then, enough time should be given in order to more accurately check the incoming goods and indicators of the supplier performance. In addition, it is also advisable to send a written warning to the supplier. When a medium risk level occurs, it is recommended to supervise and monitor the deliveries at the time they are supplied. If the suppliers are classified as those to represent a negligible risk, no special actions are recommended.

Tab. 5 contains data about the suppliers as provided by the companies. Using the guidelines from Tab. 4, the values of probability and effect on the quality and safety of finished products were estimated and Equation 2 was applied to assess the overall risk associated with the particular supplier. The results show that none of the three validated enterprises cooperate with a supplier who could be defined as a severe risk supplier. Most suppliers ranked as representing a moderate or a negligible risk level. Only two suppliers were assessed as being at the critical risk level, namely the suppliers supplying pork and beef meat to the meat processing plant. They delivered large amounts of perishable raw material prone to contamination with zoonotic agents; so, the score assigned to this category was 25. Moreover, the deliveries from the pork supplier frequently caused complaints due to insufficient quality; thus, the score assigned to this category was 20. Pork is especially prone to foodborne hazards such as *Salmonella, Staphylococcus aureus*, and *Clostridium perfringens* [19]. Therefore, Wang et al. [29] suggested that the pork deliveries are CCP, even though no 100 % check for the occurrence of pathogenic bacteria is feasible, while Asefa et al. [2] defined it as a Control Point. At any rate, special supervision over those deliveries of such raw materials is compulsory, and a conformity certificate should accompany each shipment of raw pork [29]. Even in small pork processing plants, the application of ISO 22000 is of assis-

tance, when developing effective hazard control methods [19]. According to Leat et al. [13], the cooperation between producers and retailers may cause the vulnerability of the supply chain of pork to decrease.

In the case of the beef suppliers, a high risk was found in two criteria: delayed deliveries and complained deliveries. This fact can be linked to the currently observed trend in Europe where beef consumption gradually decreases and customer concerns about beef quality increases [27]. The beef safety is affected by a possible contamination by pathogens such as *Salmonella*, pathogenic *E. coli* (STEC, EHEC) [23] and it is necessary to implement an effective traceability system [5]. Therefore, in the meat plant, where the research was carried out, the assessed risk related to deliveries of beef of questionable quality was the highest. The suppliers of milk and lamb were ranked as the moderate risk level suppliers and the rest of suppliers were assessed as posing a negligible risk to the quality and safety of finished products.

Risks associated with the suppliers of the dairy plant had only moderate or negligible effects on the quality and safety of products manufactured in this plant. Even the risk related to the supplier of powdered milk (bulk raw material) was found to have little if any negative effect on the quality and safety of the finished products. In its form for suppliers, the above mentioned dairy plant declared to have implemented the ISO 22000 food management safety system; so, the risk associated with deficiencies in the safety management systems was estimated as minimal. The dairy plants in Poland have been paying a lot of attention to the high quality of their products for many years and have implemented systems to assure food safety; this fact beneficially impacted the quality level of their products [11]. The implementation of management systems improves the level of food safety and decreases risks [18].

In the catering facility, except for the supplier who delivered sausages, all the suppliers represented a negligible level of risk. According to the documents provided, all the suppliers of this company implemented the HACCP system and the suppliers of cheese and onions implemented systems of quality management. Soriano et al. [24] showed that the implementation of the HACCP system improves the microbiological quality of meals. Catering facilities, which used an appropriate method to assess risk connected with the suppliers, paid very much attention to the quality of raw materials and carefully chose their suppliers [14].

The management of food safety and quality in companies should begin with identifying risks; next, preventative methods should be developed to control them. Of those methods, the selection of suppliers and the monitoring of their performance is an essential part. In many studies, there are described various methods to assess suppliers. For example, Ghodsypour and O'Brien [7] used "FAHP", a fuzzy analytic hierarchy process, to choose a supplier and they assessed the following criteria: costs, quality,

Table 5. Testing results of risk assessment method in three companies
Tabela 5. Wyniki testowania metody oceny ryzyka w trzech zakładach

Level of probability (P), impact (E), risk of one criterion (R_K) Poziom prawdopodobieństwa (P), wpływu (E), ryzyka jednego kryterium ($R_{K)}$	P	E	R_C	P	E	R_C	P	E	R_C	P	E	R_C	P	E	R_C	P	E	R_C
Meat plant / Zakład mięsny																		
Criterion / Supplier Kryterium / Dostawca	Packages Opakowania			Starch Skrobia			Pork Wieprzowina			Milk Mleko			Bee Wołowina			Mutton Baranina		
Category of supplier Kategoria dostawcy	2	2	4	4	4	16	5	5	25	5	5	25	5	5	25	5	5	25
Number of years of cooperation with supplier Liczba lat współpracy z dostawcą	1	1	1	1	1	1	2	1	2	2	1	2	1	1	1	1	1	1
Delayed deliveries Dostawy opóźnione	1	3	3	1	3	3	1	3	3	1	3	3	3	3	9	3	3	9
Outstanding deliveries Dostawy niezrealizowane	1	2	2	1	2	2	2	2	4	1	2	2	1	2	2	1	2	2
Complained deliveries from one supplier Dostawy zareklamowane od jednego dostawcy	1	5	5	1	5	5	4	5	20	2	5	10	4	5	20	1	5	5
Foods safety and quality assurance and management systems Zapewnienie bezpieczeństwa i jakości oraz systemy zarządzania	2	2	4	2	2	4	2	1	2	2	1	2	2	1	2	2	1	2
Risk level (R) Poziom ryzyka (R)	19 Negligible Nieistotny			31 Negligible Nieistotny			58 Critical Krytyczny			46 Moderate Umiarkowany			61 Critical Krytyczny			46 Moderate Umiarkowany		
Dairy plant / Zakład mleczarski																		
Criterion / Supplier Kryterium / Dostawca	Lids 1 Wieczka 1			Lids 2 Wieczka 2			Cups 1 Kubki 1			Cups 2 Kubki 2			Sugar Cukier			Powdered milk Mleko w proszku		
Category of supplier Kategoria dostawcy	2	2	4	2	2	4	2	2	4	2	2	4	5	5	25	5	5	25
Number of years of cooperation with supplier Liczba lat współpracy z dostawcą	1	1	1	1	1	1	1	1	1	1	1	1	3	1	3	5	2	10

Delayed deliveries Dostawy opóźnione	3	3	9	1	3	3	1	3	3	1	3	3	1	3	3	1	3	3
Outstanding deliveries Dostawy niezrealizowane	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2
Complained deliveries from one supplier Dostawy zareklamowane od jednego dostawcy	3	5	15	1	5	5	2	4	8	2	5	10	1	5	5	1	5	5
Foods safety and quality assurance and management systems Zapewnienie bezpieczeństwa i jakości oraz systemy zarządzania	2	2	4	2	2	4	2	2	4	2	2	4	2	2	4	0	0	0
Risk level (R) Poziom ryzyka (R)	35 Negligible Nieistotny			19 Negligible Nieistotny			22 Negligible Nieistotny			24 Negligible Nieistotny			42 Moderate Umiarkowany			45 Moderate Umiarkowany		
Catering facility / Zakład gastronomiczny																		
Criterion / Supplier Kryterium / Dostawca	Hamburgers Hamburgery			Buns Bułki			Cheese Ser			Sausages Parówki			Onion Cebula			Lettuce Sałata		
Category of supplier Kategoria dostawcy	5	5	25	5	5	25	5	5	25	5	5	25	5	5	25	5	5	25
Number of years of cooperation with supplier Liczba lat współpracy z dostawcą	1	1	1	1	1	1	3	1	3	1	1	3	1	1	1	1	1	1
Delayed deliveries Dostawy opóźnione	1	3	3	1	3	3	1	3	3	1	3	3	1	3	3	1	3	3
Outstanding deliveries Dostawy niezrealizowane	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2	1	2	2
Complained deliveries from one supplier Dostawy zareklamowane od jednego dostawcy	1	5	5	1	5	5	1	5	5	3	5	15	1	5	5	1	5	5
Foods safety and quality assurance and management systems Zapewnienie bezpieczeństwa i jakości oraz systemy zarządzania	2	2	4	2	2	4	0	0	0	2	2	4	0	0	0	2	2	4
Risk level (R) Poziom ryzyka (R)	40 Negligible Nieistotny			40 Negligible Nieistotny			38 Negligible Nieistotny			52 Moderate Umiarkowany			36 Negligible Nieistotny			40 Negligible Nieistotny		

suppliers profile, and risk factors. Amid et al. [1] used "FGP", a fuzzy goal programming, to set an appropriate quantity of orders placed with particular suppliers and they took into account the lowest prices and the highest quality. Laeequddin et al. [12] de-

veloped a trust building model through risk evaluation in a supply chain and the data were analysed using multiple regression analyses. However, the above mentioned methods are not well known to the Polish food industry, neither are they very common in small and medium size companies in the European Union. According to ISO 9004 [8], not every single supplier must go through an audit by the customer company but each one should be assessed. Auditing is a time-consuming process and requires that many auditors are employed or auditing agencies are hired. Many companies only audit the suppliers of high risk raw materials. Nowadays, many companies purchase raw materials from wholesalers and brokers [28], and consequently, those wholesalers should also be audited.

For the last 10 years, the supply chain management has been one of the most studied issues [30]. Global market competition puts pressure on companies to manage their supply chains in an optimal way. The quality of the supply chain not only depends on good management in purchasing high-quality materials but, also, on good management to ensure the quality and punctuality of deliveries and control of costs, as these also affect the quality of the finished product and the competitiveness of a particular company. That is why, for many companies, the management of purchases is deemed to be one of their most important tasks [6].

The method presented in this paper can help assess the risk associated with a particular supplier in a simple way. According to the quantitative model by Berger et al. [3], the companies should use a few suppliers but they have to be assessed and analyzed [8]. For the optimal performance, food processing companies should use the services of the best suppliers of raw materials and improve the culture of food safety and quality [21] by monitoring the quality of the deliveries and by regularly assessing the performance of their suppliers. The method as proposed here would probably work even more efficient in the case the suppliers have been surveyed for at least 6 or even 12 months. Then, the quality of the raw materials supplied would be even better. This method also permits the monitoring of the cooperation with suppliers and it would reduce the risk of failures at the level of suppliers, which, in turn, would impact the quality of finished products. What's more, this special method of assessing the suppliers takes into account the economic factor as it records the frequency of those deliveries, which are delayed or cancelled.

It can also be used to prepare a company-specific standard operation procedure to ensure high performance of the suppliers in terms of the quality and safety of deliveries and services. The response from the companies participating in the present study indicates they would welcome this method and widely apply it. Moreover, it will help draw attention to the important role the supplier plays in the cooperation with the food producers and distributors in order to meet the ISO 9004 requirements. This method is very flexible and can be adjusted according to the specific needs of companies. Our

study leaves room for future applications. All what remains is to analyze the individual criteria of probability and effect. The limitations of using our method consists in that employees with poor knowledge and little experience may not be able to appropriately use our methodology. Also, there is a need for more validation in practice.

Conclusions

1. A simple method was proposed to assess risk of the effect of particular suppliers on the quality and safety of finished food products.
2. The method of assessing the supplier-associated risk was validated in three food processing companies. None of their suppliers was found to have a very strong negative effect on the safety and quality of the final product.
3. Our method of risk assessment can be applied to assess suppliers in different food businesses. However, it is necessary to verify this method in a wider group of food businesses.
4. There are essential limitations of using our method, e.g. knowledge and awareness of the potential users.

References

[1] Amid A., Ghodsypour S.H., O'Brien C.: Fuzzy multi-objective linear model for supplier selection in a supply chain. Int. J. Prod. Econ., 2006, 104 (2), 394-407.
[2] Asefa D.T., Kure C.F., Gjerde R.O., Langsrud S., Omer M.K., Nesbakken T., Skaar, I.: A HACCP plan for mycotoxigenic hazards associated with dry-cured meat production processes. Food Control, 2011, 22 (6), 831-837.
[3] Berger P.D., Gerstenfeld A., Zeng, A.Z.: How many suppliers are best? A decision analysis approach. Omega-Int. J. Manage. Sci., 2004, 32 (1), 9-15.
[4] Costantino N., Pellegrino R.: Choosing between single and multiple sourcing based on supplier default risk: A real options approach. J. Purch. Supply Manag., 2010, 16 (1), 27-40.
[5] Feng J., Fu Z., Wang Z., Xu M., Zhang X.: Development and evaluation on a RFID-based traceability system for cattle/beef quality safety in China. Food Control, 2013, 31 (2), 314-325.
[6] Florez-Lopez R.: Strategic supplier selection in the added-value perspective: A CI approach. Inform. Sciences, 2007, 177 (5), 1169-1179.
[7] Ghodsypour S.H., O'Brien C.: A decision support system for supplier selection using an integrated analytic hierarchy process and linear programming. Int. J. Prod. Econ., 1998, 56-57 (1), 199-212.
[8] PN-EN ISO 9004:2010. Zarządzanie ukierunkowane na trwały sukces organizacji. Podejście wykorzystujące zarządzanie jakością.
[9] Jacob C.J., Mathiasen L., Powell D.A.: Designing effective messages for microbial food safety hazards. Food Control, 2010, 21 (1), 1-6.
[10] Kołożyn-Krajewska D., Dolatowski Z., Zielińska D.: Probiotika in Fleischprodukten. Fleischwirtschaft, 2012, 92 (4), 101-108.
[11] Konecka-Matyjek E., Turlejska H., Pelzner U., Szponar L.: Actual situation in the area of implementing quality assurances systems GMP, GHP and HACCP in Polish food production and processing plants. Food Control, 2005, 16 (1), 1-9.
[12] Laeequddin M., Sardana G.D., Sahay B.S., Waheed K.A., Sahay V.: Supply chain partners trust building through risk evaluation: the perspectives of UAE packaged food industry. Supply Chain Manag., 2009, 14 (4), 280-290.

[13] Leat P., Revoredo-Giha C.: Risk and resilience in agri-food supply chains: The case of the ASDA PorkLink supply chain in Scotland. Supply Chain Manag., 2013, 18 (2), 219-231.
[14] Legnani P., Leoni E., Berveglieri M., Mirolo G., Alvalo N.: Hygienic control of mass catering establishments, microbiological monitoring of food and equipment. Food Control, 2004, 15 (3), 205-211.
[15] Linthorst M.M., Telgen J.: Public purchasing future: Buying from multiple sources. In: Advancing Public Procurement: Practices, Innovation and Knowledge-Sharing. Eds. G. Piga, K.V. Thai. PrAcademics Press, Boca Raton, Florida, 2007, pp. 471-482.
[16] Luning P.A., Marcelis W.J., Jongen W.M.F.: Food Quality Management: A Techno-managerial Approach. Wageningen Press, Wageningen 2002.
[17] Meena P.L., Sarmah S.P., Sarkar A.: Sourcing decisions under risks of catastrophic event disruptions. Transport. Res. E-Log., 2011, 47 (6), 1058-1074.
[18] Morkis G.: Zakres wdrożenia obligatoryjnych systemów zapewnienia bezpieczeństwa zdrowotnego i zarządzania jakością w przedsiębiorstwach przemysłu spożywczego w Polsce. Żywność. Nauka. Technologia. Jakość, 2012, 5 (84), 203-214.
[19] Poumeyrol G., Rosset P., Noel V., Morelli E.: HACCP methodology implementation of meat pâté hazard analysis in pork butchery. Food Control, 2010, 21 (11), 1500-1506.
[20] Powell D.A., Erdozain S., Dodd C., Costa R., Morley K., Chapman B.J.: Audits and inspections are never enough: A critique to enhance food safety. Food Control, 2013, 30 (2), 686-691.
[21] Powell D.A., Jacob C.J., Chapman B.J.: Enhancing food safety culture to reduce rates of foodborne illness. Food Control, 2011, 22 (6), 817-822.
[22] Regulation (EC) No. 178/2002 of the European Parliament and of the Council of 28 January 2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety. OJ L 31, pp. 1-24, of 01.02.2002.
[23] Rhoades J.R., Duffy G., Koutsoumanis K.: Prevalence and concentration of verocytotoxigenic *Escherichia coli*, Salmonella enterica and *Listeria monocytogenes* in the beef production chain: A review. Food Microbiology, 2009, 26 (4), 357-376.
[24] Soriano M., Rico H., Molto J.C., Manes J.: Effect of introduction of HACCP on the microbiological quality of same restaurants meals. Food Control, 2002, 13 (4-6), 253-261.
[25] Trafiałek J., Pawłowska J.: Analiza efektów szkolenia pracowników firmy cateringowej z wdrożonym systemem zarządzania bezpieczeństwem żywności, zgodnym z normą ISO serii 22000. Żywność. Nauka. Technologia. Jakość, 2013, 1 (86), 217-229.
[26] Trafiałek J., Przybylski W.: Analysis of risk exposure to carcinogenic diseases from pork meat. Fleischwirtschaft Intern., 2011, 26 (4), 73-78.
[27] Van Wezemael L., Verbeke W., Kügler J.O., Barcellos M.D., Grunert K.G.: European consumers and beef safety: Perceptions, expectations and uncertainty reduction strategies. Food Control, 2010, 21 (6), 835-844.
[28] Wallace C., Sperber W., Mortimore S.E.: Food Safety for the 21st Century: Managing HACCP and Food Safety throughout the Global Supply Chain. Willey Blackwell, Oxford, United Kingdom, 2011.
[29] Wang D., Wu H.N., Hu X.T., Yang M.L., Yao P., Ying Ch.J., Hao L.P., Liu L.G.: Application of Hazard Analysis Critical Control Points (HACCP) system to vacuum-packed sauced pork in Chinese food corporation. Food Control, 2010, 21 (4), 584-591.
[30] Xia W., Wu Z.: Supplier selection with multiple criteria in volume discount environments. Omega-Int. J. Manage. Sci., 2007, 35 (5), 494-504.

OCENA DOSTAWCÓW W SEKTORZE ŻYWNOŚCIOWYM: CZY JEST METODA SZACOWANIA RYZYKA?

S t r e s z c z e n i e

Celem pracy było opracowanie łatwej do zastosowania metody oceny ryzyka związanego z dostawcami w sektorze żywnościowym. Metoda zaproponowana w pracy umożliwia obliczenie poziomu ryzyka współpracy z danym dostawcą w prosty matematyczny sposób. Ocena ryzyka bazuje na sześciu kryteriach dla każdego dostawcy: rodzaju towarów lub produktów dostarczanych przez dostawcę, czasie współpracy z dostawcą, systemach stosowanych przez dostawcę do zagwarantowania jakości i bezpieczeństwa, opóźnionych i odwołanych dostawach, zareklamowanych dostawach z powodu nieodpowiedniej jakości surowców. Metoda została zwalidowana w trzech zakładach: mięsnym, mleczarskim i gastronomicznym. Zaproponowano prostą metodę oceny ryzyka danego dostawcy w aspekcie wpływu na jakość i bezpieczeństwo produktu. Metoda może być stosowana w zakładach różnych branż. Największą korzyścią zaproponowanej metody jest jej łatwość stosowania oraz funkcjonalność. Może być wykorzystana w małych zakładach i nie wymaga stosowania skomplikowanych obliczeń, czy zaawansowanych statystycznych narzędzi. Metoda może być bardzo pomocna w przedsiębiorstwach, ale ma pewne ograniczenia, jak wiedza i świadomość użytkowników.

Słowa kluczowe: dostawca, ryzyko, ocena ryzyka, bezpieczeństwo żywności, jakość żywności zagrożenie