

The British Retail Consortium Global Standard for Food Safety enjoys great popularity among food industry companies, the number of companies with the certified standard is rising every year. The packaging used for food packaging has a very large impact on the safety and quality of the packaged food. The purpose of the study was to indicate the requirements of the standard in relation to packaging, which should be implemented firstly by enterprises of the food industry. In the research part, the AHP analysis was conducted on the basis of the experts' recommendations. Decision matrices for every criterion: hazard analysis concerning packaging, purchase procedure, packaging acceptance procedure were developed. A decision matrix for the main criterion as a result of criteria decision matrix was developed, global decision hierarchy was also developed. Research clearly showed that the most important activity (among the proposed) is hazard analysis, with a 0.517 weighted sum value. In many of the detailed requirements of the standard, hazard analysis and risk assessment (0.333 weighted sum value) are the basis for many activities, including establishing a purchasing procedure (0.163 weighted sum value), accepting packaging (0.297 weighted sum value), or many others. The relevance of this study is the identification of the hierarchy of importance of activities performed within the framework of ensuring the quality and safety of food packaging. A reasonable approach is presented. The AHP method allows indicating the sequence of activities during the implementation of the BRC standard, as evidenced by pilot studies carried out on the basis of procedures related to the safety of packaging. The standard sets up requirements for packaging in the form of packaging management procedure, in which it should be stated how the site operates with packaging. Moreover, there are requirements concerning hazard analysis in relation to packaging

Keywords: BRC Food Safety, BRC standard, food packaging, food safety assurance

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DEVELOPMENT OF RECOMMENDATIONS ON THE HIERARCHY OF ACTIVITIES REGARDING THE IMPLEMENTATION OF THE BRC STANDARD IN RELATION TO THE SAFETY OF PACKAGING USING THE AHP METHOD

Agnieszka Kawecka

PhD, Doctor of Economic Science,
Associated Professor*

Agnieszka Cholewa-Wójcik

Corresponding author

Habilitated Doctor of Management and Quality
Sciences, University Professor*

E-mail: cholewaa@uek.krakow.pl

Tadeusz Sikora

Professor of Agricultural Sciences, Professor**

Department of Process Management

* Department of Packaging **

**Institute of Quality and

Product Management Science

Cracow University of Economics

Rakowicka str., 27, Kraków, Poland, 31-510

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1. Introduction

The aim of the European Union food safety policy is to provide EU citizens with safe, high-nutritional food, while ensuring that the food industry – the largest manufacturing and employment sector in Europe – can operate under the best possible conditions. Ensuring food safety is one of the basic challenges that the food industry must cope with. Systems and standards for quality assurance and food safety are one of the most effective ways to ensure safety. Providing safe food depends on many factors. Among these factors, the safety of materials and packaging of them that are used for food is of great importance. The process of ensuring safety can be called a sequence of actions aimed at ensuring con-

fidence that the requirements for the safety of packaging materials and packaging, and packaged food are met.

The Polish market and other European Union markets are based on the principle of liability of the producer or other entity placing the product on the market. The producers are committed to placing only safe materials and packaging on the market.

Producers and distributors who obtained information that the packaging material or packaging placed on the market is not safe are obliged to immediately notify the relevant supervision authorities, i. e. the relevant poviatsanitary supervision inspector, and allow the packaging to be withdrawn from the market by delivering precise information identifying the material or batch of materials that may be used to determine the course of material and packaging turnover.

Due to the important role of packaging in ensuring the quality of packaged food, issues related to the requirements for manufacturers of packaging and packaging materials intended for food are included in the BRC standard.

The British Retail Consortium Global Standard for Food Safety enjoys great popularity among food industry companies. This standard is required for producers and other food holders which are suppliers to retail networks. Due to the fact that in the majority of cases packaging is an integral element of the product, packaging used for food products must be covered by the standard, because packaging has a significant impact on food safety. Therefore, legal requirements have been adopted, compliance with which ensures the safety of materials and packaging intended for food packaging. The standard was created to help producers meet their legal obligations, as well as ensure the protection of consumer interests. This standard pays special attention to the quality and functional aspects of packaging. It includes requirements for hygiene, production environment and packaging testing.

The standard includes requirements not only for food packaging materials, but also for all packaging manufacturers.

The implementation of food quality and safety assurance systems is a set of activities and processes that a company must carry out. In small and medium-sized enterprises, management often encounters the problem of insufficient funds to implement all tasks at the same time. This causes a number of decision problems that must be faced by the management of food industry companies. Due to the lack of clear and transparent guidelines regarding the sequence of implementation of individual measures, it would be helpful to establish an appropriate, effective sequence of implementation of individual activities. The relevance of the study is the identification of the hierarchy of importance of activities performed within the framework of ensuring the quality and safety of food packaging.

2. Literature review and problem statement

The works presented in the literature on ensuring the safety and quality of food and its packaging concern such areas as: control activities related to ensuring food safety, implementation of food safety systems and standards, risk analysis and system implementation barriers. The study [1] presents core control and assurance activities as addressed by food safety management. The role of different levels of execution of control and assessment activities was underlined. The topic is also visible in the paper [2]. The work only identifies activities ensuring safety without indicating their importance.

The paper [3] indicates that control and assessment activities need to be evaluated concerning their performance and relevance. However, in [4], attention is drawn to a set of system requirements that should be evaluated and, if necessary, changed. The work does not address directly the problem of the sequence in which the indicated actions are implemented.

One of the fundamental requirements of the BRC Food Safety standard is the development of a food safety plan covering activities related to programs commonly regarded as elementary nowadays, these are Food Safety, Food Defense and Food Fraud, relations between them are presented in [5, 6]. Indications of connections and differences in the area of ensuring security, but without aspects related to their implementation. Chapter [7] in reference to packaging safety turns attention to

the introduction of tamper-evident packaging on the market in order to increase the level of safety of the packed products and instill confidence in consumers in the quality of food products. The paper [8] continues this subject focusing on prevention in the food supply chain. The considerations concern solutions affecting the safety of packaged goods, however, they do not apply to activities undertaken in enterprises.

Packaging is an extremely important element of hazard analysis, as raw materials, additives and water should be subject to special supervision. The work [9] states that analyzing the risks associated with packaging, it is necessary to create a list of all hazards, including those that may be caused by packaging. Packaging can be a source of contamination of a physical, chemical and biological nature. This is also described in accordance with European legal regulation, in [10]. There is a lack of description of the relationship between the hazard analysis and other activities from the spectrum that ensures the safety and quality of packaging.

In addition, it should be taken into consideration how the packaged products can be protected from fraud by the packaging (deliberate/intentional adulteration of food) and against intentional contamination of the product [1]. Packaging can also be a source of allergens and such risks should also be analyzed. The papers [11, 12] note that risk assessment should take into account the impact of packaging on the quality of the final product. This assessment forms the basis for the approval and testing of packaging as well as suppliers' approval and monitoring processes. Selected hazards are described in detail in the study, indicating preventive actions, without analyzing the actions influencing safety in its entirety. According to the standard [13] and regulation [14], this analysis should be updated, particularly in cases where the packaging or the packaging supplier has been changed, if there are reports of new packaging risks, after the product has been withdrawn from the market or complaints were made, if the reason for the recall was the packaging. In a situation where nothing has been changed or any disturbing signals regarding the packaging used, risk assessment should be repeated every 3 years. The provision of traceability of direct packaging is an extremely important requirement. In addition to the requirement of the standard, it should be remembered that this is a legal requirement. Also, the paper [15] turns attention to the list of packaging suppliers and the list of requirements for packaging must be available. Approval parameters and test rates must be precisely defined, implemented and reviewed. This problem is dealt with fragmentarily and does not provide a complete picture of the ways in which the safety of the packages is ensured.

The paper [16] points to the still incomplete implementation of systems and standards in food industry enterprises in Europe. In addition, it is proven that the implementation of safety management systems improves the level of hygiene, employee awareness and the overall level of safety of the food offered. However, the increasing costs related to the implementation and maintenance of the system were also indicated.

Barriers to implementing safety management systems are also a topic discussed in the literature, including [17], where attention was drawn to the shortages of resources and adequate knowledge in enterprises.

The literature review gives an incomplete picture of activities and solutions in the field of packaging safety assurance. The simultaneous implementation of many activities necessary from the point of view of BRC is a great diffi-

culty in terms of management and operation of enterprises, because it forces the involvement of human and financial resources and may lead to a lack of organizational order. This problem of safety assurance activities implementation hierarchy is crucial for enterprises in the food sector.

3. The aim and objectives of the study

The aim of this research is to develop a hierarchy of activities regarding the implementation of the BRC standard in relation to the safety of packaging, moreover using the AHP method. The result is the adaptation of an AHP method, which is widely used in decision-making problems in other fields of study and practice but firstly used in solving safety assurance problems.

To accomplish the aim, the following objectives were set:

- development of decision matrix for each criterion as a result of criteria decision matrix;
- development of decision matrix for the main criterion as a result of criteria decision matrix;
- global decision hierarchy elaboration.

4. Materials and methods

The Analytical Hierarchy Process (AHP) allows you to create an appropriate vector of priorities. At the same time, it gives the opportunity to interpret the preferred information from the decision-maker based on the pairwise comparison value of a set of objects. Since pairwise comparison values are judgments derived from an appropriate semantic scale, in practice policy-makers typically report some or all of the pairwise comparison values with a degree of uncertainty rather than with accurate ratings. The AHP method is a method that allows you to decompose complex decision problems and create a ranking for a finite set of variants. Thanks to this method, it is possible to solve many decision-making problems, including those related to the area of food safety management in the enterprise [18, 19]. The research part focuses on the AHP (Analytic Hierarchy Process) comparison of the four basic procedures that are required in the BRC standard. The AHP method has four stages [20]:

1. Building a decision model in the form of a hierarchical structure.
2. Collection of primary data using a nine-point comparison scale.
3. Estimation of weight coefficients for each comparison matrix together with consistency check.
4. Aggregation of judgments or priorities in group decision-making.

The first stage of the AHP method is the construction of a decision model, which in the AHP theory is referred to as a hierarchical structure. The hierarchy can be used to present most of the decision problems, so one can talk about the universality of the hierarchical structure. The concept of hierarchy is related to the valuation and comparison of "objects". Therefore, they can be defined as the preferential ordering of individual objects constituting a comparative system. In the AHP method, creating a hierarchical model consists in decomposing the decision problem into elements, grouping these elements into homogeneous clusters, and then assigning these sets to the appropriate levels of the hierarchy according to the relations between them.

The finished hierarchical model should be analyzed, which in the AHP method is done using a special pairwise comparison scale called Saaty's Fundamental Scale or 9-point pairwise comparison scale. Pairwise comparisons are used to establish relative preferences, n-item/item advantages, in situations where it is impractical or even impossible to determine ratings by using direct ranking. So, when direct ranking is inadvisable. In the AHP method, the pairwise comparisons use a scale with 9 intensities of advantage of one element over the other, from 1 (the same importance of the elements) to 9 (total advantage).

The third stage concerning the estimation of weighting factors can be carried out with the use of selected methods of mathematical analysis, e. g. PC matrix.

Aggregation in group decision-making can be implemented on the basis of two ways of aggregating opinions: qualitative (behavioral) methods, quantitative (mathematical) methods.

The decision model in the AHP theory is perceived as a hierarchical structure, a hierarchical system or a decision hierarchy. The hierarchical model in the AHP method is a structure consisting of four levels [21]:

- the decision-making purpose, that is, the state the decision-maker wants to achieve after solving a given decision problem;
- decision criteria, defined as sub-objectives;
- sub-criteria, which are the most important factors for the decision-maker in the;
- implementation of the given objective and the choice of the decision-making option, decision options – a set of at least two objects or scenarios.

After developing the aforementioned hierarchical model, it was analyzed using the pairing scale called the Saaty's fundamental scale. These analyses are very simplified, only for the initial analysis of the hierarchy of procedures. The comparisons were made using the AHP Online System software [22]. The AHP can be defined as a process of hierarchizing a system in order to carry out a wide-ranging evaluation and final selection of one of the alternative solutions to a particular problem. The method can also be understood more broadly as a theory of measurement using quantitative and/or qualitative data [23]. As a comprehensive safety evaluation method, AHP has been used in various fields of safety science such as mine safety, traffic safety and public safety. Priorities were indicated by seven specialists (experts) in the field of packaging of goods, who based on their knowledge and experience in the field of packaging materials and packaging for food contact, by assessing and comparing the validity of specific procedures on a 9-point scale, created the matrix presented in Table 1. AHP scale used in the analysis: 1 – Equal Importance, 3 – Moderate importance, 5 – Strong importance, 7 – Very strong importance, 9 – Extreme importance (2, 4, 6, 8 values in-between) [24].

In the AHP method, one of the basic statistic measures showing convergence in judgments is CR (Consistency Ratio).

$$CR = \frac{CI}{RI};$$

$$CI = \frac{\lambda_{\max} - N}{N - 1},$$

where RI – random index based on the random consistency index ($RI=0.09$ for four parameters); λ_{\max} – represents the

largest eigenvalue; N – size of comparison matrix. In this study, $N=4$.

Consistency Ratio of the obtained matrix is on the level of $8.8\%=0.088$. According to congested values for CR should be less than 0.1, this condition is fulfilled [21].

The first step of the research was to establish the most suitable order of implementing procedures concerning packaging. Procedures, which are fundamental in the BRC standard, were identified: hazard analysis concerning packaging, purchase procedure, accepting packaging procedure, control of physical contamination. The evaluation of the importance of sub-criteria leads to a complete evaluation of the criteria and the selection of the most important activities. The outcome of the whole study should be the hierarchy of procedures, with consideration of their importance. The general diagram of the research is presented in Fig. 1.

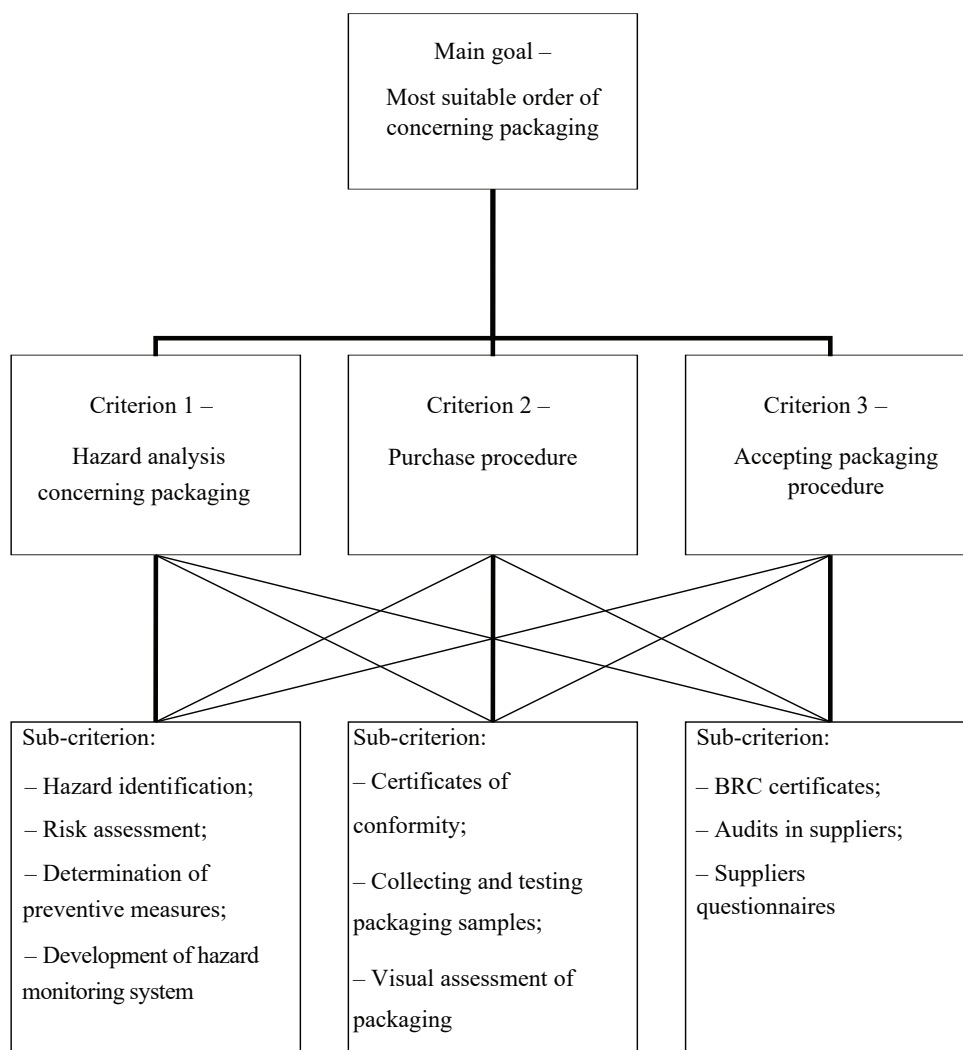


Fig. 1. Diagram of the research with the main goal, criteria and sub-criteria

The diagram in Fig. 1 shows the main goal, criteria and sub-criteria, assumed in the research. Criteria are the main processes in the packaging safety assurance system. Sub-criteria are activities realized within each process. The diagram is a fundament of AHP analysis, the main goal of which is activities hierarchy concerning safety assurance.

5. Results obtained in the AHP method concerning safety assurance activities

5.1. Decision matrix for each criterion using the AHP method

For each packaging procedure, an assessment of the importance of sub-criteria making up the main objective criteria was performed. As part of the hazard analysis, the criteria were assessed (hazard identification, risk assessment, determination of preventive measures, development of hazard monitoring system). In order to create a decision matrix, experts in the field of packaging were selected, whose task was to determine the validity of individual procedures based on their own knowledge and experience. Experts' indications were the basis for creating a decision matrix for each of the assessed procedures. The results are presented in Table 1.

The analysis of the results of pairwise comparisons presented in Table 1 showed that the pairs of the following categories obtained the highest mean values of scores: Hazard identification – Determination of preventive measures and Hazard identification – Development of hazard monitoring system (value 6.0). Relatively high scores were also obtained by the pairs of categories: Risk assessment – Determination of preventive measures, Risk assessment – Development of hazard monitoring system (value 5.0). The number of performed comparisons was 6, consistency ratio CR was 1.2 %.

Subsequently, the purchase procedure assessed the criteria (suppliers questionnaires, BRC certificates and audits in suppliers). The results are presented in Table 2.

The analysis of the results of pairwise comparisons presented in Table 2 showed that the pair of categories: BRC certificates – Supplier questionnaire (value 5.0) obtained the highest mean values of ratings. Relatively high scores were also achieved by the pair of

categories: Audits in suppliers – Supplier questionnaire (value 4.0). The number of performed comparisons was 3, consistency ratio CR was 2.6 %.

As part of the packaging acceptance procedure, the criteria were assessed (certificates of conformity, visual assessment of packaging, collecting and testing packaging samples and certificates of analysis). The results are present-

ed in Table 3. The analysis of the results of pairwise comparisons presented in Table 3 showed that the highest values of the average scores were obtained by the pair of categories: Certificates of conformity – Visual assessment of packaging (value 8.0). Relatively high scores were also awarded for the pairs of categories: Collecting and testing packaging samples – Visual assessment of packaging and Certificates of analysis – Visual assessment of packaging (value 6.0). The number of performed comparisons was 6, consistency ratio CR was 0.8 %.

Table 1

Decision matrix for hazard analysis concerning packaging criterion

Category	Hazard identification	Risk assessment	Determination of preventive measures	Development of hazard monitoring system
Hazard identification	1	2.00	6.00	6.00
Risk assessment	0.50	1	5.00	5.00
Determination of preventive measures	0.17	0.20	1	1.00
Development of hazard monitoring system	0.17	0.20	1.00	1

Table 2

Decision matrix for purchase procedure criterion

Category	Supplier questionnaire	BRC certificate	Audits in suppliers
Supplier questionnaires	1	0.20	0.25
BRC certificates	5.00	1	2.00
Audits in suppliers	4.00	0.50	1

Table 3

Decision matrix for packaging acceptance procedure criterion

Category	Certificate of conformity	Visual assessment of packaging	Collecting and testing packaging samples	Certificate of analysis
Certificates of conformity	1	8.00	2.00	2.00
Visual assessment of packaging	0.12	1	0.17	0.17
Collecting and testing packaging samples	0.50	6.00	1	1.00
Certificates of analysis	0.50	6.00	1.00	1

5. 2. Development of decision matrix for the main criterion as a result of criterion decision matrix

To develop a decision matrix for the main criterion, suitable ranking was made. The results are presented in Table 4.

The number of performed comparisons was 3, consistency ratio CR was 1.0 %. The obtained result proves that there is sufficient information about the examined problem, and the decision model has been preserved properly structured.

Table 4

Decision matrix for main criterion

Category	Hazard analysis concerning packaging	Purchase procedure	Packaging acceptance procedure
Hazard analysis concerning packaging	1	3.00	2.00
Purchase procedure	0.33	1	0.50
Packaging acceptance procedure	0.50	2.00	1

5. 3. Global decision hierarchy

Comprehensive results of AHP analysis concerning full packaging safety program are presented in Table 5.

Table 5

Global decision hierarchy

Level 0	Level 1	Level 2	Global Priority
Packaging safety program	Hazard analysis concerning packaging 0.540	Hazard identification 0.517	27.9 %
		Risk assessment 0.333	18.0 %
		Determination of preventive measures 0.075	4.0 %
		Development of hazard monitoring system 0.075	4.0 %
	Packaging acceptance procedure 0.297	Certificates of conformity 0.454	13.5 %
		Collecting and testing packaging samples 0.250	7.4 %
		Certificates of analysis 0.250	7.4 %
		Visual assessment of packaging 0.046	1.4 %
	Purchase procedure 0.163	BRC certificates 0.570	9.3 %
		Audits in suppliers 0.333	5.4 %
Supplier questionnaires 0.097		1.6 %	

The obtained results show priority of each activity, in the opinion of experts, concerning packaging safety program. As the most important, hazard identification (global priority ratio 27.9 %), risk assessment (18.0 %) and certificates of conformity (13.5 %) were indicated. As activities with average importance, BRC certificates (9.3 %), collecting and testing packaging samples (7.4 %), certificates of analysis (7.4 %) and audits in suppliers (5.0 %) were indicated. The least important were determination of preventive measures (4.0 %), development of hazard monitoring system (4.0 %), suppliers questionnaires (1.6 %), visual assessment of packaging (1.4 %).

6. Discussion of results concerning the hierarchy of activities in the field of ensuring safety

The attempt to use the AHP method to indicate the hierarchy of activities in the area of ensuring the safety of packaging confirmed its usefulness and possibility of use in food industry enterprises. The obtained research results were divided into three stages.

In the first task, the development was made: decision matrix for hazard analysis concerning packaging criterion, decision matrix for purchase procedure criterion, decision matrix for packaging acceptance procedure criterion. Each of them gives a fundament to the second research task.

On their basis, the decision matrix for the main criterion was developed. Hazard analysis concerning packaging has obtained the highest score in comparison to packaging acceptance procedure (3.0 points), purchase procedure (2.0 points). Hazard analysis is the most important activity in enterprises concerning BRC standard implementations because it gives the start to preventive actions and the whole plan of safety assurance. It is compatible with the Hazard Analysis and Critical Control Point system in accordance with FAO/WHO Codex Alimentarius.

In the task of development of global decision hierarchy, the research results indicated that the priority activities in the field of ensuring safety are: hazard identification (0.517 weighted sum value) and risk assessment (0.333 weighted sum value). Hazard identification and analysis and risk assessment contain the key requirements and information for developing complete descriptions of safety, quality and product integrity activities and processes in the company. They are carried out by competent and qualified hazard analysis and risk assessment teams by identifying the hazards, which then develop and implement the necessary measures to prevent hazards. The threats that are identified concern a very wide spectrum – microbiological, chemical, physical, foreign bodies, defects critical to consumer safety, use of recycled materials by the manufacturer. In addition, the threats to product safety include the migration of substances from packaging materials to food or other hygiene-sensitive products (e. g. packaging for cosmetics), threats that may affect the integrity of packaging, or problems related to malicious intervention or adulteration of raw materials. Based on a detailed risk assessment, critical points and control points in production processes are determined and a plan is created to eliminate or control them. It is possible to use different methods of risk assessment. Properly conducted analysis and control is a necessary condition that determines the safety of packaging.

This is also confirmed by the analyses presented in the literature on the subject of ensuring food safety. The obtained test results confirmed that the AHP method is a decision support method in the area of ensuring the safety and quality of packaging and can be useful for:

- determining the order (ranking) of variants in terms of their importance of procedures;
- determining the strength of the influence of the indicated factors on the final result of ensuring food packaging safety.

It should be clearly stated that the AHP method provides a convenient approach to solving complex problems in the area of ensuring the safety of food packaging. Thus, the application of the AHP method allowed for the definition of priority actions that should be taken in the first place to ensure food safety [25, 26]. The use of the AHP method in the food sector is becoming increasingly popular and covers more and more areas. The AHP method is used to evaluate suppliers to determine the best supplier of a food producing company [27].

In the study, experts were very consistent in their assessment. Consistency Ratio in every decision matrix was very low, and never had a value above 3%. However, it is possible to imagine on the contrary, when the experts do not agree, their assessments differ significantly. Then question the sense of conducting this type of assessment. This means that evaluators should be experts in the field, which reduces the likelihood of a discrepancy between evaluators. Therefore, the barrier to conducting research is access to experts with a significant level of competence. It is also preferable to involve more experts in the assessments. One of the disadvantages of this study can be acquiring highly qualified experts in this thematic area.

7. Conclusions

1. The realization of the decision matrix for each criterion as a result of the criteria decision matrix is a step that allows conducting the next task concerning the development of the decision matrix for the main criterion as a result of the criteria decision matrix. The research showed a large compatibility of experts regarding the validity of the activities presented. The CR coefficient for the conducted evaluations was in the range from 0.8 to 2.6%, which indicates a large convergence in expert judgments.

2. Development of decision matrix for the main criterion as a result of criteria decision matrix allowed to state that there is a possibility of determining the order of implementation of actions regarding food packaging safety. The AHP method allows indicating the sequence of activities during the implementation of the BRC standard, as evidenced by pilot studies carried out on the basis of procedures related to the safety of packaging. There is a large differentiation of the indications of the importance of individual activities, which allows us to determine what is the starting point for determining the priority of actions taken. Many real decision problems are related to many criteria in the qualitative domains. As expected, such problems will increasingly be modeled as multi-criteria decision problems that include scoring in subjective/qualitative domains. Therefore, the possibility of using the AHP method in practice in the area of ensuring food packaging safety will become more and more important.

3. Global decision hierarchy elaboration allows determining the relevance of individual activities important for enterprises that begin the process of implementing the standard and often cannot assess in which order the measures should be taken. Therefore, establishing a universal hierarchy of necessary actions is support and help in implementing the requirements of the standard. As the most important in packaging safety program, hazard identification, risk assessment and certificates of conformity were indicated. These actions are the basis in BRC standard implementation.

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