



**PRODUCTION MANAGEMENT  
and PACKAGING  
Food Safety and Industry 4.0**

**Edited by**

**Anna Walaszczyk  
Irena Jałmużna  
Jerzy Lewandowski**

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# CONTENTS

<b>Introduction</b> .....	4
<b>Internal audit as an assessment tool and a way to improve the quality management system</b> .....	5
<i>Wiktor Adamus, Jan Szewczyk</i>	
<b>Comparative analysis of the life cycle of a pet bottle and a biodegradable bottle</b> .....	27
<i>Patrycja Baldowska-Witos</i>	
<b>Intelligent aspects of packaging in food industry</b> .....	34
<i>Natalia Bartczyk, Monika Robak, Barbara Galińska</i>	
<b>Food safety in the supply chain: theory and practice</b> .....	46
<i>Daniel Chudzik, Andrzej Szymonik</i>	
<b>Visions and directions for the development of logistics 4.0 in context 4.0 industrial revolution (level 4.0 – I.4.0)</b> .....	69
<i>Bożena Gajdzik</i>	
<b>The presence of a magnetic separator and the efficiency of the process</b> .....	80
<i>Irena Barbara Jalmużna, Piotr Lewandowski</i>	
<b>Consumers' perception of eco-innovation in food supply chain logistics as a factor shaping food product quality</b> .....	92
<i>Krzysztof Kud</i>	
<b>The prospect for the use of biodegradable polymers as a modern and proecological packaging materials</b> .....	105
<i>Malgorzata Latos-Brozio, Anna Masek</i>	
<b>Biodegradable and bio-based thermoplastics as sustainable materials for packaging production</b> .....	114
<i>Olga Mielcarek, Anna Masek</i>	
<b>The influence of financial problems on the implementation of logistic processes in a production enterprise – case study</b> .....	123
<i>Włodzimierz Połoz</i>	
<b>Plastic packaging as a component of circular economy</b> .....	135
<i>Aneta Szumicka</i>	
<b>The effect of packaging on microbiological quality of dried fruit</b> .....	142
<i>Katarzyna Śliżewska</i>	
<b>Intelligence IP right – Resume Best Practice</b> .....	150
<i>Malgorzata Znhyalewska-Traczyk, Manishkumar Saini</i>	

## INTRODUCTION

After mechanization (first revolution), electrification (second revolution) and digitization (third revolution), the time has come to integrate systems and create networks. The issues of the so-called the fourth industrial revolution – Industry 4.0 is a very topical topic. According to this approach to the industry, it is the realization of an intelligent factory in which cyber-physical systems control physical processes, create digital copies of the real world and make decentralized decisions, and through the Internet of things in real time communicate and cooperate with each other and with people, Industry 4.0 integrates people and digitally controlled machines with the Internet and information technologies. What is the impact on the food industry? Will food security benefit from this revolution?

These and other questions can be answered in articles published within the framework of the monograph, which is the result of an exchange of knowledge and experience between the participants of the International Conference on Production Management and Packaging - ICPM-PP 2018 under the title Food Safety and Industry 4.0.

We hope that the results of research, case studies and literature studies in the field of the undertaken issues, contained in the monograph, will provide you with added value.

Anna Walaszczyk  
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Jerzy Lewandowski

# INTERNAL AUDIT AS AN ASSESSMENT TOOL AND A WAY TO IMPROVE THE QUALITY MANAGEMENT SYSTEM

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**Abstract:** The aim of the paperwork is to present the idea of internal audit in the process of assessment and improvement of the quality management system. The research hypothesis was given to verification: Internal audit is an effective tool to assess and improve the quality management system and the company's functioning. The empirical research was made at Przedsiębiorstwo Pszczelarsko-Farmaceutyczne Apipol-Farma. The research covered a period of five years, from 2010 to 2014. To verify the research hypothesis, the analysis of internal audit results and audit follow-up activities undertaken was made. The concepts of internal audit, its objectives and types were presented and compared to the essence of quality, quality management and the process of the company's continuous improvement. The characteristics of the implemented quality management system at *Apipol-Farma* were presented. The process of internal audit in the surveyed organization was identified and the implementation of audit follow-up activities in the context of empirical research was presented. A statistical analysis of trends in internal audits in the analysed period in terms of the number of non-compliances found was made. Based on the conducted research, there were no grounds to reject the research hypothesis.

**Keywords:** internal audit, improvement, non-compliance, management system.

## 1. Introduction

Quality management is related to continuous improvement of an organization, and should be implemented based on an analysis of facts collected during direct research. Internal audit is an important tool in efficient organization management that allows for an effective assessment of the company's activities and constitutes a source of data for undertaking improvement actions. Moreover, it allows for a comprehensive, continuous inspection and assessment of implemented processes, which in turn leads to detection of non-compliance, wastage and high costs. *Audit* is a systematic, independent and documented process of obtaining audit evidence and its objective assessment to determine the extent to which audit criteria have been met. *Internal audits* are an integral part of the quality management system and play an important role in the improvement of its actions. It is a tool that allows for an effective assessment of the company

and is a source of data for undertaking continuous improvement activities, aimed at increasing the ability to meet the requirements set before the organization.

The aim of the paperwork is to present the idea of internal audit in the process of assessment and improvement of the quality management system. The empirical research was carried out at Przedsiębiorstwo Pszczelarsko-Farmaceutyczne *Apipol-Farma* Sp. z o.o. in which the integrated quality management system compliant with the requirements of PN-EN ISO 9001:2009 and the GMP principles was established, documented, implemented and maintained. The research covered a period of five years, from 2010 to 2014.

The *np* card shows the influence of interfering factors, however, it does not cause any irregularities in the course of the process. All values are within the control limits. The process can be considered statistically regulated, which in the analysed period proceeds correctly.

## **2. The concept of quality**

Quality is a concept that is complex and differently defined in literature. The meaning of this word has changed over time and is variously explained, depending on profession [1]. The definition of quality by J.M. Juran, who believed that quality is the ability of a product to meet the client's needs, is considered to be the appropriate concept. This ability is obtained by giving a product a certain group of characteristics and properties determined and required by the client [1]. Despite the very large variety of quality definitions, their common feature is an indirect or direct connection to the field of usability, which is connected with defining requirements as consumer needs [2].

The PN-EN ISO 8402:1996 standard defines quality as overall properties of an object, which are related to its ability to satisfy identified and expected needs. According to A. Kiliński, quality in a general sense means type, species, property of an object or a feature that distinguishes one object from another [3]. Despite the very broad variety of quality definitions, their common feature is an indirect or direct connection to the field of usability, which is connected with defining requirements as consumer needs [2].

## **3. The essence of quality management**

There are many management strategies that directly or indirectly affect quality. According to L. Wasilewski, quality management is not an isolated discipline of science or knowledge. As it develops, it is more and more intertwined with other disciplines, using their achievements and introducing new principles or synthesis of experiences [4]. Quality management covers the life cycle of a product from market research to service. Repeating this cycle serves production development and its quality, which is referred to as the spiral of quality [5]. This type of management also includes tasks and activities of the top management necessary to implement the quality policy and objectives [6]. Quality management

is a timeless activity and should be treated as a style of life and being of an organization's employees [7]. According to the PN-EN ISO 9000:2006 terminological standard, quality management is: "coordinated activities targeted at management and supervision of an organization in relation to quality" [8]. The creator of the concept of comprehensive quality management, A.V. Feigenbaum, claims that modern quality management allows achieving effects in five spheres of activity [4]. Quality management is now perceived as a global management subsystem. Quality management is not just a strategy. It is a way of life, giving something to society, giving the best of yourself to others [9]. Modern quality management may be offensive (show focus on customers) and defensive (be product oriented) [9]. The scope of global quality management includes technical, social and economic aspects. The social aspect is related to the management's attitude, team work, management style, training and an atmosphere of openness. The technical aspect includes market research, quality policy, audit, quality control techniques. Quality costs and value analysis are an economic aspect [9].

The PN-EN ISO 9001:2009 terminological standard indicates the client and its needs in between ten and twenty points describing the requirements of the quality management system. The purpose of the standard is to constantly provide products that meet customer requirements and strive to increase this satisfaction. The increase in customer satisfaction can be achieved by using a system, continuous improvement processes and compliance with customer and law requirements [10]. Customer-orientation is related to understanding its needs and the needs of interested parties, the so-called pre-emptive quality. The concept of perfection is closely related to quality management. Perfection is a very complex concept. Its nature is defined in many fields and scientific disciplines. However, the complexity of perfection does not mean that this is an ambiguous concept, because its sense has been relatively stable for a long time [11]. Perfection can be considered in relation to material objects, as well as to non-material ones [12]. The quality management system should be based on continuous improvement in accordance with Deming's cycle and kaizen principles [13]. J. Juran included the approach to improvement in ten steps [9]. The quality improvement program should be directed to a given organization as well as its surroundings. According to J. Juran, quality can only be achieved by implementing the right projects for its improvement throughout the organization. He proposes the so-called trilogy, which includes: quality planning, quality control and quality improvement [13]. A management system cannot be maintained if it is not subjected to a continuous improvement process. The PN-EN ISO 9001:2009 terminological standard indicates seven mechanisms of improvement [15]. Continuous improvement is associated with consistent activities that consist in pursuing the goal. These activities will change with market development, regulations, technology, customer awareness [16]. The process of change and improvement is inscribed in a company's day-to-day functioning [17]. Quality improvement includes activities that aim to increase the efficiency and effectiveness of processes and procedures covered by the quality management system. Continuous improvement is a process

of preventing defects. It is a continuous process based on Deming's cycle. The quality management system should be based on continuous improvement in accordance with Deming's cycle and kaizen principles [13]. J. Juran included the approach to improvement in ten steps. Based on the research made by T. Borys and M. Rogala, it can be stated that the most important direction of improvement in enterprises is the increase in the efficiency of operations. It is equally important to increase employee engagement, operational efficiency and customer satisfaction. Other, but less important, directions of organization's improvement include: increasing operational efficiency, increasing management's commitment, reducing the number of inconsistencies, reducing the number of documentation, and increasing an organization's overall safety [15].

#### **4. Audits of quality management systems**

The term "quality audit" was introduced in 1972 for the first time to the third edition of the European Organization for Quality Control [18], and then the definition of audit was given in the ISO 9001:1987 standard. It has been translated into Polish as inspection [19].

Internal audits are one of the main areas on which a company should focus its operations [20]. They are considered one of the techniques required by the ISO 9001 standard. Their main purpose is to check compliance with the requirements of ISO 9001 [21].

According to the later terminology adopted in the PN-EN ISO 9000:2006 standard, audit is a systematic, independent and documented process of obtaining audit evidence and its objective assessment to determine the extent to which audit criteria have been met [8]. Audit evidence means entries, statements of fact or other information that are relevant to the audit criteria and are verifiable [8]. B. Kromer defines internal audit as an effective tool for implementing and improving the quality management system in an organization, which allows for quick and correct correction of existing non-compliances in processes [22]. According to the International Association of Auditors, an audit is "independent, objective assurance and advisory activity, carried out to bring added value to an organization and improve its functioning [23]. However, many other definitions of the concept of quality audit can be found in literature. J. Dunn believes that an internal audit is an independent unit created within an organization to study and analyse its activities. It is developed to help in the effective fulfilment of tasks by members of an organization [24]. In turn, L.R. Howard defines an internal audit as part of the internal control system. This system is created by managers for the purpose of research, assessment and reporting on operational controls [25].

An audit is not a control and the purpose of an audit is not to seek guilty parties [26]. Audit is not a concept that would be equivalent to control, despite the fact that very often these processes are considered equivalent due to the goal related to actions and the compliance of the actual actions with the planned ones [22]. Control consists in comparing the current state with the required one. Its

purpose is to identify errors and act in situations of crisis [36]. Based on the numerous audit definitions made, it can be seen that the quality audit is not limited to the quality area only. It is treated as a universal tool for monitoring and controlling an organization [27]. The primary objective of the auditing process is to collect objective evidence for compliance with certain standards, requirements and regulations [28]. A. Hernas treats audit as a real research made to determine the effectiveness and adequacy of the system, where the emphasis is put primarily on progress [29]. Internal audit is an action to check whether all conditions necessary for the effective functioning of the management system have been preserved [30]. The purpose of an audit is not only to detect as many non-compliances as possible, but to obtain an answer to the question about their causes [31]. According to A. Kleniewski, internal audit is one of the most important, potential sources of added value. The recipients of added value are all interested parties, which is why it is very important to jointly prepare an audit, implement and report it. Each type of audit should answer the question whether the system is compatible, effective and efficient [32]. Internal audit, as a tool used to diagnose functioning, has found a very wide application in the modern organization management. It is used in relation to various areas of its activity [33].

According to H. Grocholski, the task of an internal audit is to provide the manager with objective information on the functioning of an organizational unit, control systems, risks and implementation of improvements to increase efficiency and effectiveness [34]. Audits can be divided according to many different criteria [35]. The first party audit is called internal audit. It is made on the initiative of the top management of the organization for its own needs. It can be the basis to declare compliance by an organization [36]. Only this type of audit is mandatory in the quality management system assessment [18]. This results directly from the PN-EN ISO 9001:2009 standard. The purpose of internal audits is to assess whether the quality management system complies with the requirements of the ISO 9001 standard, and the decisions adopted within an organization, and whether it is effectively implemented and maintained.

The PN-EN ISO 9004:2010 standard also covers issues related to internal audits [37]. Due to the item that is subjected to assessment, internal audits can be divided into [36]: quality system audit, standard point audits, process audits, product audits, service audits, organizational unit audits. The quality system audit concerns checking whether the implemented quality management system is effective, whether legal provisions and requirements of standards are followed [28]. The organizational unit audit is a basic audit, which also includes organizational connections [36]. The process audit involves checking the selected process related to the company's functioning. It is used to simplify processes and make them more transparent, reduce process costs and improve communication between entities that participate in the process. Production, supply or sales processes are most often assessed [28]. The essence of process auditing is to examine whether courses and rules form a logical organization, arranged in

a sequence of creative activities that allow for goal achievement, create added value and run optimally [38].

The product audit is recommended for product improvement in the design and manufacturing phases [36]. The procedure audit confirms the compliance of the adopted procedure with documentation and circulation of documents [22].

The second party's audits are carried out by parties interested in the organization. The most special type of audit is the third party audit. These audits are carried out by independent external organizations [36]. Accredited units are authorized to carry out such audits, and they confirm the compliance of the system with specific requirements. The result of such an audit is assignment of a certificate or taking it away if non-compliance with the criteria is observed [28].

The information collected during an audit constitutes audit evidence, which is then assessed in relation to audit criteria, which in turn leads to making conclusions from the audit. Audit findings may indicate compliance or non-compliance with audit criteria. All discrepancies found should be reviewed with an auditee to obtain confirmation that the audit evidence is accurate and that non-compliances are understandable [PN-EN ISO 19011:2012].

## **5. Characteristics of the quality management system at PP-F. Apipol-Farma Sp. z o.o.**

Przedsiębiorstwo Pszczelarsko-Farmaceutyczne *Apipol-Farma* Sp. z o.o. has been operating on the pharmaceutical market since 1991. The company is a leader in the production of OTC drugs, dietary supplements and cosmetics based on natural raw materials such as honey, honey herb, pollen, propolis, beehive, royal jelly, bee venom and wax. *Apipol-Farma* has its own production plant in Myślenice near Kraków, equipped with a physicochemical and microbiological laboratory. A wide range of bee raw materials gives unlimited possibilities for the company to create various products with targeted preventive action while using market trends that are based on growing trust in natural medicine.

To guarantee the proper quality and purity of bee raw materials, a quality assurance system called the *Apipol System* was developed and implemented by the company. The system describes subsequent production stages occurring in apiaries, taking into account those hazards that may have a significant impact on the quality of products. In 2000, *Apipol-Farma* received the ISO 9001 and HACCP certificates awarded by the TUV Rheinland certification body. Since 2010, the organization has a certificate confirming compliance with the requirements of ISO 22 000. In 2006, the Main Pharmaceutical Inspector confirmed that the plant met the GMP requirements by issuing an appropriate certificate. *Apipol-Farma* also puts great emphasis on development and dissemination of apitherapy by undertaking activities aimed at acquiring a wide range of specialists in the field of medicine and pharmacy. The company's activity includes research on new possibilities of using raw materials of bee origin in medicine, as well as in the food and cosmetics industries. The company

has established, documented, implemented a management system, whose effectiveness is constantly improved in accordance with the requirements of ISO 9001: 2008 *Quality Management Systems. Requirements*. The Company has established and maintains a *Quality Manual* approved for mandatory use by the Chief Executive. The manufacture of safe products for consumers' health is achieved by following the rules of the HACCP system. Critical control points for the health safety of the final product are defined at each production stage. The *Quality Management System* at PP-F. *Apipol-Farma* is documented and described in such documents as the declaration of quality policy and quality objectives, *Quality Manual*, procedures required by ISO 9001:2008, standard operating procedures, process course plans, instructions and forms.

Focusing on the health and customer satisfaction as the main goal of the established policy, the Management Board at *Apipol-Farma* has adopted the production of dietary supplements, foodstuffs for special nutritional and medical purposes, medical devices, medicinal products and cosmetics, always compliant with legal provisions, specifications, recipes and fulfilment of expectations and customer requirements. The quality goals at *Apipol-Farma* are set for relevant functions and at appropriate levels of management. The goals are measurable, consistent with the quality policy, and determined measurably where possible.

In accordance with procedure PZ-SOP-7.4.02. *Audit at the supplier*, audits at suppliers of active substances and auxiliary substances are carried out during qualification, reclassification of the supplier, and in case of deterioration of the quality of supply. The company has planned and implemented a process of monitoring, measurement, analysis and improvement. Its purpose is to demonstrate products' compliance with requirements and to improve the effectiveness of the quality management system. The manufacture of safe products for consumers' health is achieved by following the rules of the HACCP system, aimed at identification and elimination of chemical, physical and microbiological hazards which may cause a decrease in the health quality of manufactured products. At each production stage, critical control points for health safety of the final product are defined.

## **6. The internal audit process at PP-F. Apipol-Farma Sp. z o.o.**

External audits carried out for the client by its employees or on its behalf by an external entity take place in the company. The purpose of such an audit is to check whether the auditee is able to meet the requirements set by the auditor. Due to the company having a certificate confirming compliance of the quality management system with the requirements of the PN-EN ISO 9001:2009 standard, third party audits are carried out by the TÜV Rheinland certification body. What is more, the plant is also subject to periodic inspection made by inspectors of the Main Pharmaceutical Inspectorate, inspectors of the Main Sanitary Inspectorate, and inspectors monitoring the safety of medicinal products. The purpose of the internal quality audit procedure is to ensure a planned,

systematic and independent inspection of compliance, efficiency, effectiveness and maintenance of the quality management system to meet the requirements and other assumptions and system goals, as well as documenting the above activities.

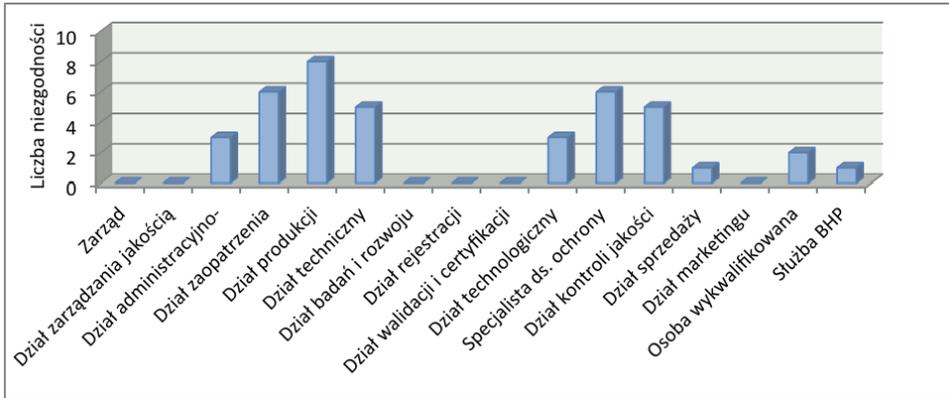
An internal audit in an enterprise begins with an opening meeting with the participation of a team of auditors and auditees to discuss the audit program. Next, under the guidance of the lead auditor, the team of auditors conducts a practical test based on *Audit Plan* F-8.2.2/03 and *List of audit questions* F-8.2.2/04. As part of a practical test, auditors conduct job interviews, verify records, documents and compare oral explanations with information obtained from observations and records. They fill in the answers they have received into the *list of audit questions*, they make notes containing information and observations, and formulate detected discrepancies. Non-compliances and/or comments are determined in relation to individual requirements of the standard or other related documents based on which the audit was carried out. Conclusions from the audit indicate compliance or non-compliance with the audit criteria and identify opportunities for improvement. Discrepancies and audit evidence are recorded and summarized by the audit team. After completing the practical tests, the auditors verify non-compliances, observations and comments made during the audit. Then, the lead auditor presents them at the closing meeting. The audit is considered completed when all activities included in *the Audit Report* have been done. The head of the audited unit must accept the report as this is the basis for audit follow-up activities. The audit follow-up activities start in accordance with procedure PP-QP-8.5.2 *Corrective actions* and PP-QP-8.5.3 *Preventive actions*.

## **7. Analysis of internal audits carried out at P.P.-F. Apipol-Farma Sp. z o.o.**

The subject of internal audits carried out at the enterprise was to examine the correct functioning of individual organizational units in relation to GMP requirements and ISO 9001:2008 and ISO 22000:2005 standards.

16 internal audits were planned for 2010. In the analysed period, no non-compliances were found in five audits. The remaining ten planned audits showed non-compliances. In total, 40 non-compliances were found. The non-compliances found were mainly related to proceedings incompliant with the applicable procedures, lack of description of actions implemented in QMS documents, lack of proper records, outdated procedures and instructions.

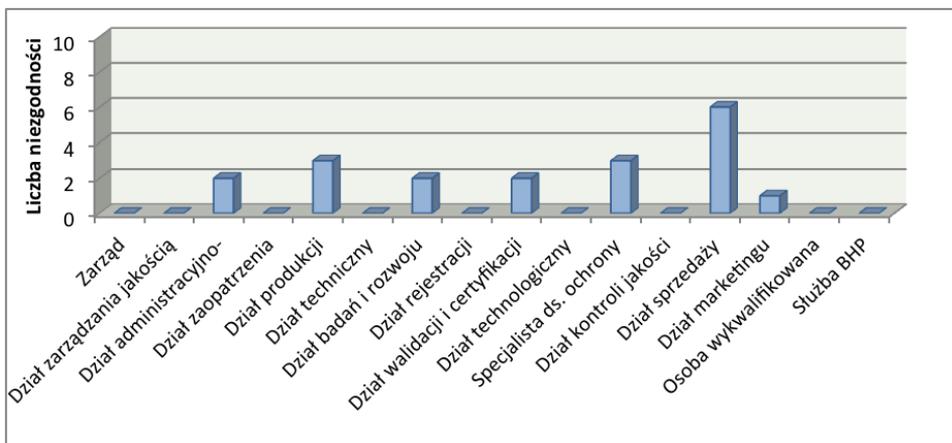
Most non-compliances occurred in connection with a procedure incompatible with the applicable procedures and instructions. The reason for this was related to the lack of updated current procedures and instructions, the lack or too low number of internal training sessions, low effectiveness of internal training, and the lack of time to check the proper course of the proceedings described in the procedures. The distribution of non-compliances identified as a result of internal audits conducted in 2009 in the company's individual organizational units is shown in Figure 1.



**Fig. 1.** The number of non-compliances found in individual organizational units of *Apipol-Farm* as a result of internal audits conducted in 2010

*Source: own study.*

Based on the collected data, it can be concluded that the greatest number of non-compliances was detected in the Production Department. Four to six non-compliances were found in the following departments: procurement, technical, quality control and at the environmental protection specialist. Departments in which no non-conformities were found: R&D Department, Validation and Certification Department, Marketing Department, Quality Management Department, Registration Department, and Management. Due to the discrepancies found, appropriate corrections and corrective actions have been planned. All activities have been implemented, their implementation has been verified and effectiveness has been assessed.



**Fig. 2.** The number of non-compliances found in individual organizational units of *Apipol-Farm* as a result of internal audits conducted in 2011

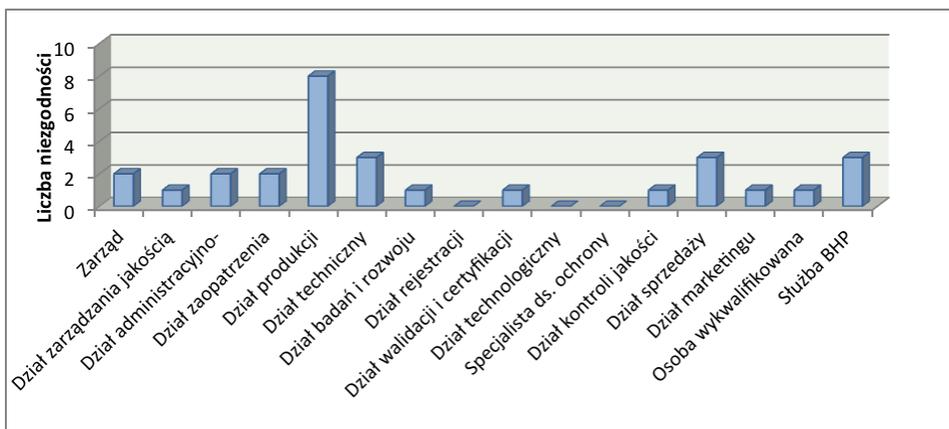
*Source: own study.*

16 internal audits were carried out in 2011. The subject of the audits was to examine the correct functioning of individual organizational units in relation to GMP requirements and ISO 9001:2008 and ISO 22000:2005 standards. The distribution of non-compliances identified as a result of internal audits conducted in 2011 in the company's individual organizational units is shown in Figure 2.

No discrepancies were found in nine audits. The remaining seven planned audits showed non-compliances. The greatest number of non-compliances was found in the Sales Department. In total, 19 non-compliances were found. The conducted analysis showed that the non-compliances found were mainly related to proceedings contrary to the applicable procedures and instructions, the lack of proper supervision over system documents, the lack of updating of the system documentation. In relation to the last analysed period, the greatest number of non-compliances concerned proceedings incompatible with the established procedures and instructions of the quality management system. The main reason for this non-compliance was the lack of employees' knowledge of the requirements contained in their procedures and instructions. A positive aspect of activities undertaken in 2011 was appointing new auditors and referring all internal auditors to external training on conducting internal audits for compliance with the requirements of EN ISO 9001: 2008. Negative aspects that could be observed in the analysed period were occurrence of non-compliances, which consist in proceedings other than those described in system documentation, lack of auditors' identification of strengths and weaknesses of the audited area and improvement proposals, incorrect classification of non-compliances, lack of management's awareness of responsibility related to issuing a corrective and preventive actions card, distinguishing between correction and corrective action and supervision over the implementation of corrective/preventive actions. Due to the observed non-compliances, appropriate corrections and corrective actions have been planned. Managers of areas in which non-compliances were found issued Corrective Action Cards. All activities have been implemented, their implementation has been verified and effectiveness has been assessed. The activities were carried out in a timely manner and in all cases the activities' correctness was assessed positively.

16 internal audits were planned for 2012. No discrepancies were found in three audits. The remaining 13 planned audits showed non-compliances. In total, 29 non-compliances were found. The ZQ proxy had 15 auditors at its disposal and it was a sufficient number to implement the Internal audits schedule.

The distribution of non-compliances identified as a result of internal audits conducted in 2012 in the company's individual organizational units is shown in Figure 3.



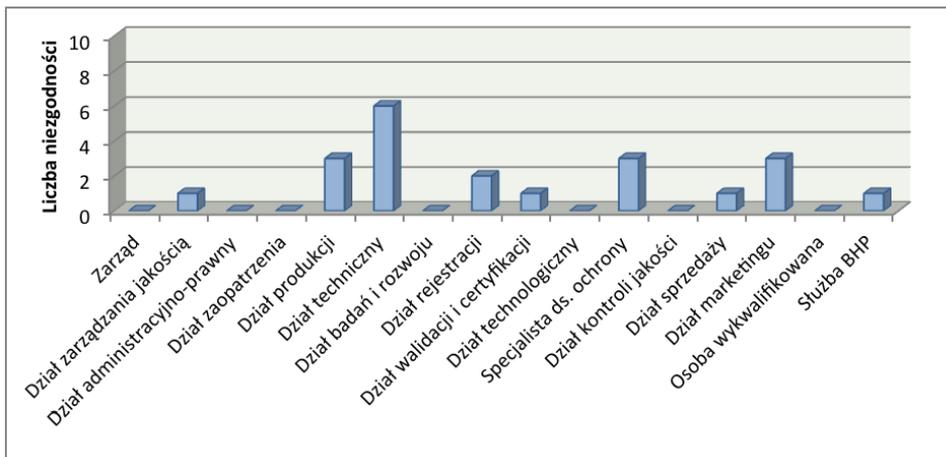
**Fig. 3.** The number of non-compliances found in individual organizational units of *Apipol-Farm* as a result of internal audits conducted in 2012

Source: own study.

Based on the analysis of obtained results, it can be stated that the highest number of non-compliances was found in the production department - eight. In the following departments: sales, technical, administrative and legal, supply, at the board and at the Health and Safety services, 2-3 non-compliances were found. In the remaining areas, one failure to meet the requirements of ISO 9001:2008 was identified. The highest number of non-compliances was related to the lack of updated procedures and instructions, non-compliance with applicable procedures and instructions, employee's lack of knowledge of specific requirements. The greatest number of non-compliances was identified in relation to outdated documents. However, this problem was particularly visible only in some organizational cells. A positive aspect of activities undertaken in 2012 was appointing new auditors and referring all internal auditors to external training on conducting internal audits for compliance with the requirements of EN ISO 22000:2005. As a result of the analysis made, it is possible to indicate several negative aspects that were observed in the discussed period: no current documentation update in force in the enterprise, lack of participation of all employees in internal as well as external training sessions, lack of identification of strengths and weaknesses of the audited area and improvement proposals, incorrect classification of non-compliances, observations, comments and suggestions for improvement. All activities have been implemented, their implementation has been verified and effectiveness has been assessed.

In 2013, the ZQ proxy had 15 auditors at its disposal and it was a sufficient number to implement the *Internal audits schedule*. In the case of seven audits, no non-compliances were found (Technology Department, Administrative and Legal Department, Supply Department, Registration Department, Qualified Persons, Quality Control Department, Management Board). The remaining 9 planned audits showed non-compliances. In total, 21 non-compliances were

found. The distribution of non-compliances identified as a result of internal audits conducted in 2013 in the company's individual organizational units is shown in Figure 4.



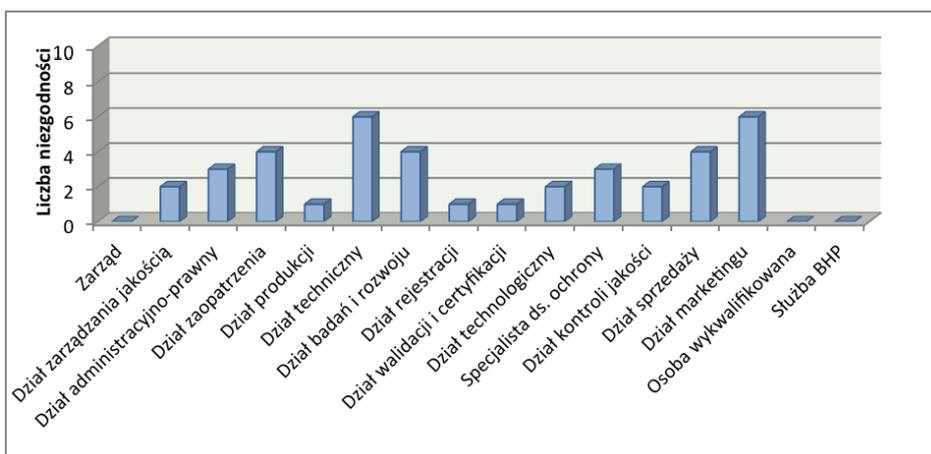
**Fig. 4.** The number of non-compliances found in individual organizational units of *Apipol-Farm* as a result of internal audits conducted in 2013

*Source: own study*

The greatest number of non-compliances was found in the Technical Department. Three discrepancies were found in the marketing and production departments and at the Environmental Protection Specialist. In the Occupational Health and Safety Service, in the sales department, quality management and validation, one non-compliance was found. The non-compliances found were related to the lack of current records, non-compliance with applicable procedures and instructions, lack of proper supervision over documents.

The highest number of non-compliances was identified in relation to the lack of current provisions in the *Employee Training Records Cards*. The same number of non-conformities was related to proceedings other than those specified in the procedures and instructions. In 2012, a lower number of non-compliances was identified in relation to the previous year.

16 internal audits were planned for 2014. For three audits, no non-compliances were found (Occupational Health and Safety Service, Qualified Persons, Board). The remaining 13 audits showed non-compliances. In total, 40 non-compliances were found. The distribution of non-compliances identified as a result of internal audits conducted in 2014 in the company's individual organizational units is shown in Figure 5.



**Fig. 5.** The number of non-compliances found in individual organizational units of *Apipol-Farm* as a result of internal audits conducted in 2014

Source: own study

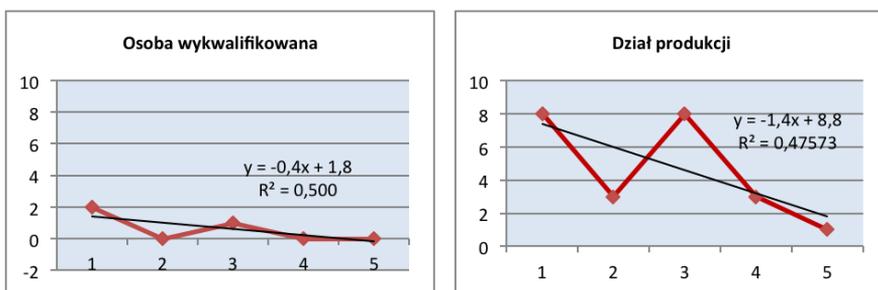
In relation to the previous year, twice as many non-compliances were identified. The qualification of non-compliances and observations was carried out by internal auditors in a correct manner. The greatest number of non-compliances was found in the Technical Department and the Marketing Department. Four non-compliances were identified in the following sections: supply, sales, research and development. The lowest number of failures to meet the requirements was found in the area of production and registration.

## 8. Statistical analysis of internal audit trends in terms of the number of non-compliances found in individual organizational units

The verification of dependence of the number of non-compliances found during the five-year study was made using statistical and mathematical methods, including; linear and non-linear econometric models, as well as Pearson's correlation and determination coefficients.

Fig. 6 shows statistical analysis of internal audit trends in terms of the number of non-compliances found in individual organizational units.

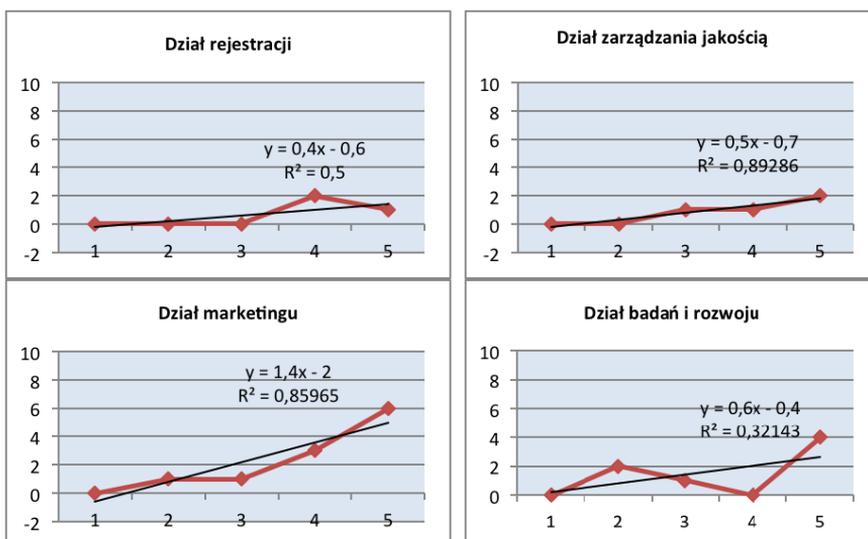
Based on the conducted analysis, it can be concluded that only in the case of two organizational units, a downward trend can be observed in the analysed period. In the *production department* and in a *qualified person*, the number of non-compliances in individual years decreased. In the production department, the number of non-compliances fell from eight in 2010 to one in 2014, while in a *qualified person* – from two to zero. In the discussed organizational cells, in both cases correlation coefficients  $r$ , which measure the strength of interdependence of two variables, have a value of 0.7, and determination coefficients  $R^2$  explain 50% of the variability of dependent variable  $Y$  (non-compliance number).



**Fig. 6.** Statistical analysis of internal audit trends in terms of the number of non-compliances found in individual organizational units

*Source: own study.*

In the case of the following departments: marketing, research and development, registration and quality management, a growing trend in the number of observed non-compliances can be observed, as shown in Figure 7.

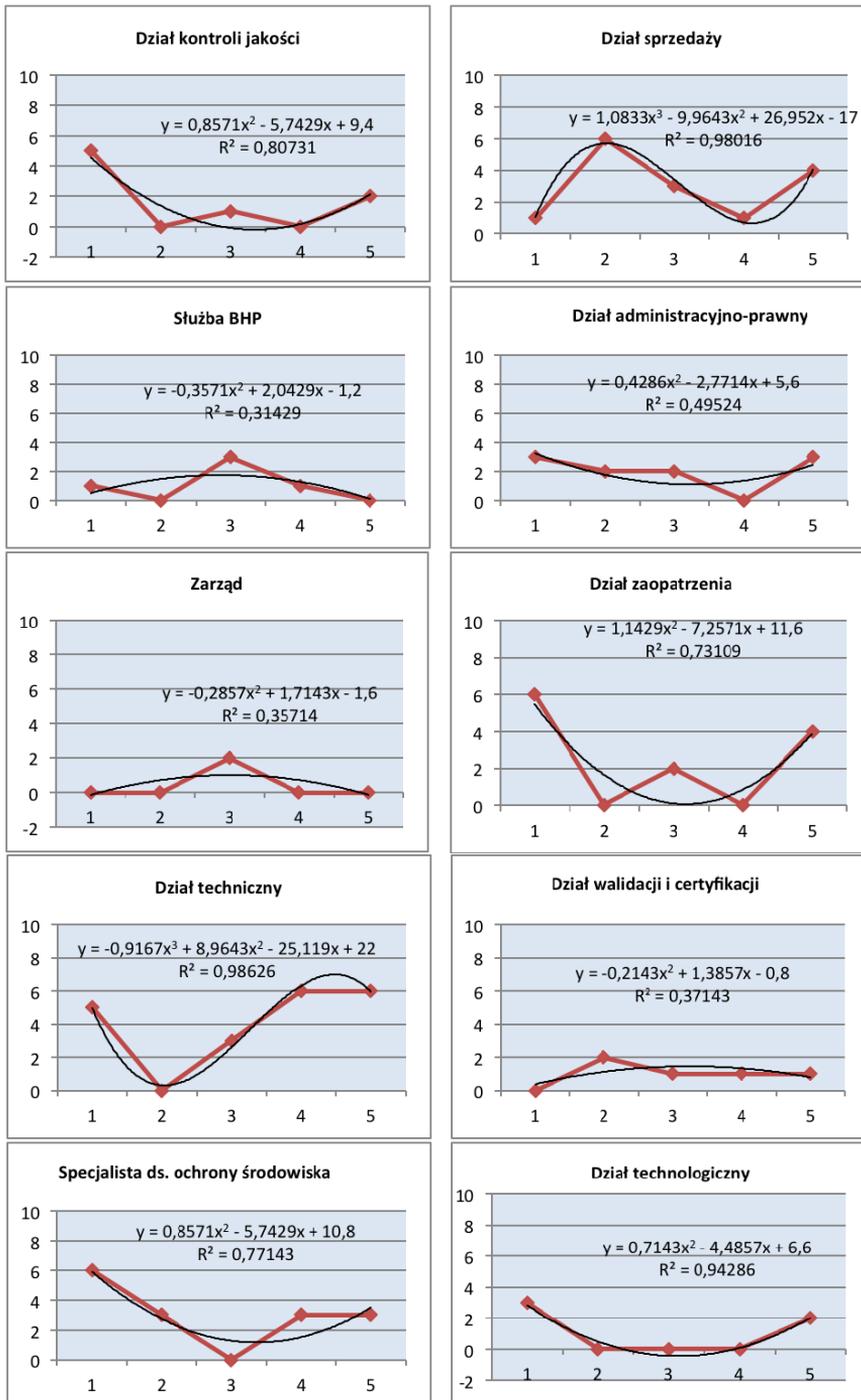


**Fig. 7.** Statistical analysis of internal audit trends in terms of the number of non-compliances found in individual organizational units

*Source: own study.*

The value of the correlation coefficient for the marketing and quality management departments is in the range of  $0,90 \leq r < 0,941$ , which indicates a high correlation.

In the company's remaining organizational units there was a polynomial dependence of the trend, as shown in Figure 8.



**Fig. 8.** Analysis of internal audit trends in terms of the number of non-compliances found in individual departments

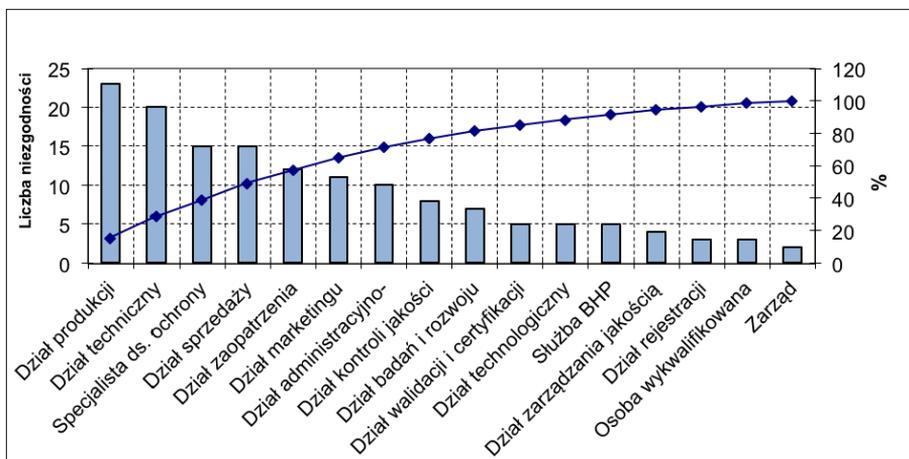
Source: own study.

Based on the analysis, it can be concluded that in the case of five departments: *quality control, technological, administration and legal, supply and environmental protection specialist*, the initial number of non-compliances found in 2010 began to decrease to zero, and then increased again in 2013-2014. An inverse dependence was observed in *the Occupational Health and Safety Service, the Management and the validation department*. After the initial drop in the number of non-compliances in *the technical department* to zero, an increase in the number of non-compliances was observed in 2012 and remained at the level of six for two years. The correlation coefficients in all organizational units took high values.

Similar analyses were made for non-compliances in relation to particular *points of the PN-EN ISO 9001:2009 standard* and non-compliances found in relation to *organization processes*.

## 9. Pareto-Lorenzo's analysis for internal audit results

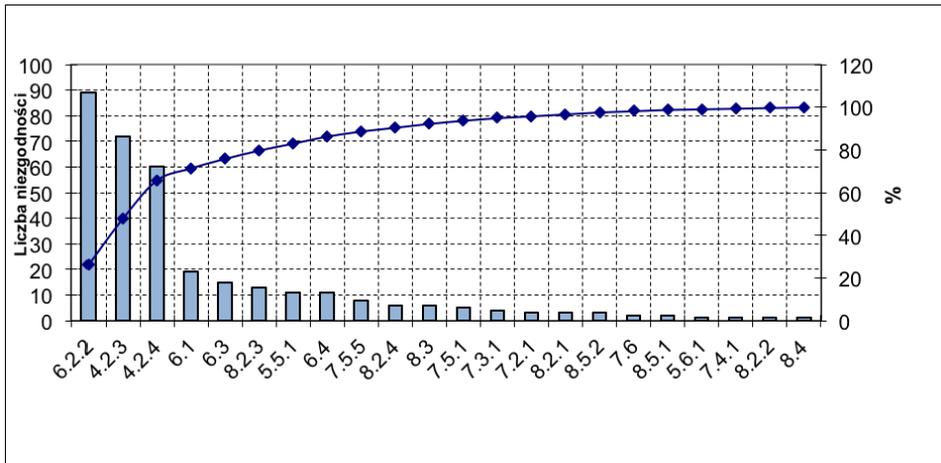
Pareto-Lorenzo's diagram is one of the basic quality tools. The Pareto principle allows finding 20% of causes of 80% of problems. In the period of 2010-2014, 80 internal audits were made in the company. The number of non-compliances in individual years was varied. Their total number over the analysed five years was 148. Pareto-Lorenzo's analysis made it possible to determine which non-compliances are the main causes of problems in a functioning quality management system. The non-compliances were arranged from the largest to the smallest to draw Pareto-Lorenzo's diagram, and illustrated in the form of a column chart. Next, the cumulative percentages of non-compliances were calculated and presented in a column chart in the form of the so-called Lorenzo's curve. Figure 9 shows Pareto-Lorenzo's diagram for the number of non-compliances found in individual company departments.



**Fig. 9.** Pareto-Lorenzo's chart. The number of non-compliances found in the years 2010-2014 in the company's individual organizational units

Source: own study based on documentation at PP-F Apipol-Farma Sp. z o.o.

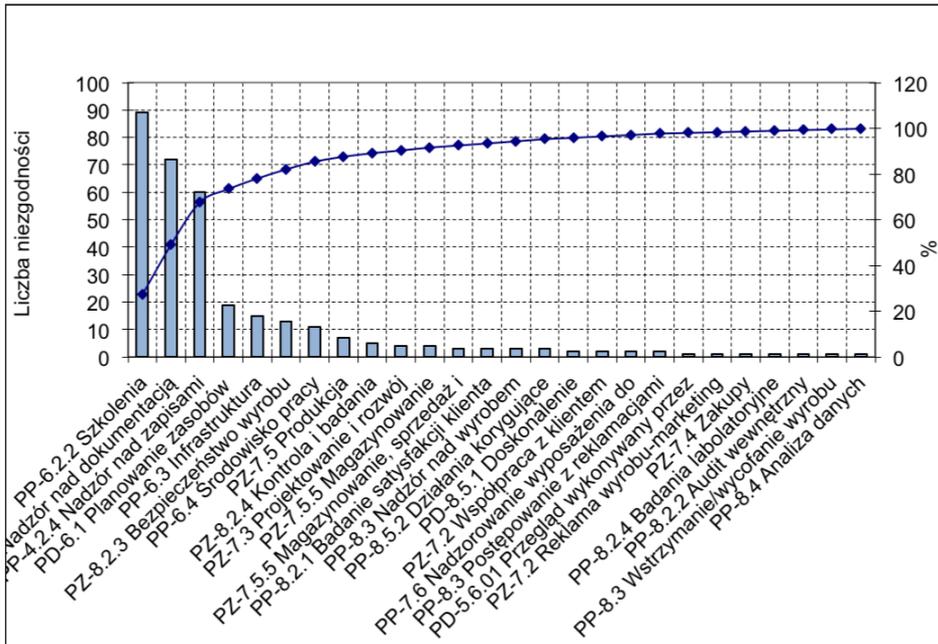
Based on the analysis, it can be concluded that the highest number of non-compliances is related to the area of production, technical and sales. These four departments (25%) generate 50% of the number of the company's non-compliances. The organization should eliminate the problems in these areas in the first place. Figure 10 presents Pareto-Lorenzo's diagram for non-compliance referred to individual points of the PN-EN ISO 9001:2009 standard.



**Fig. 10.** Pareto-Lorenzo's chart. Number of non-compliances found in the years 2010-2014 in relation to particular points of the PN-EN ISO 9001:2009 standard

*Source: own study based on documentation at PP-F Apipol-Farma Sp. z o.o.*

Analysing the obtained results, we can state that 70% of all non-compliances found in the organization are related only to three points of the PN-EN ISO 9001:2009 standard. These include: 6.2.2 *Training*, 4.2.3 *Supervision over documents*, 4.2.4 *Supervision over records*. The undertaken corrective actions should be aimed at eliminating or reducing non-compliances with the said requirements of the standard. Figure 11 presents Pareto-Lorenzo's diagram for the identified non-compliances in relation to individual processes carried out in the company.



**Fig. 11.** Pareto-Lorenzo's chart. Number of non-compliances in relation to particular processes carried out in the company

Source: own study based on documentation at PP-F Apipol-Farma Sp. z o.o.

As a result of the analysis made for the identified non-compliances in the implemented processes, the company's areas that require improvement are: *Training, Supervision over documentation, Supervision over records*. To eliminate 80% of non-compliances reported in the organization as a result of internal audits, effective corrective actions should be taken in the above-mentioned areas.

## 10. Statistical control of the internal audit process – np control card

To test the stability of the internal audit process made in 2010-2014, statistical process control was used. Due to the occurrence of random and special disturbances, the process does not proceed in a perfectly stable manner. However, certain limits within which it should be located when only random disturbances affect it can be determined. If the process goes beyond these limits at some point, it means that it has been disturbed by some other than random disturbances, i.e. special disturbances.

By determining the "natural" process behaviour, it is possible to start working on eliminating the special disturbances that affect it, causing its disregulation. A control card for controlling and supervising the process is helpful. The process flow chart on the control card reflects the behaviour of the monitored process. On its basis, it is possible to assess whether it is running properly or if it can be

disturbed by special disturbances. The chart includes the following lines: *Central line*, showing the average value of all results in the control card, *upper and lower control limit* showing the limits in which the values of the observed characteristics should be placed for the stabilized and correct process, *measured characteristic graph* presenting measured values; subsequent points are either directly measured results or average values from individual samples. *The central line* determines the average value of all collected measurements. It shows a value which is assumed on average by the measured characteristic of manufactured products. The calculation method for the central line depends on the card used. It is usually calculated as the average value of the average values of successively taken samples. *The control limits* are placed symmetrically on both sides of the central line. They are most often separated by  $3\sigma$  ( $\sigma$  of average values). The limits determine the range in which 99.73% of all measurements should be located. If any of the crossed out points exceeds such limits, it means that probably a special disturbance has occurred that needs to be identified and eliminated. Table 1 presents the total number of disturbances found in individual years of the analysed period.

**Table 1.** The number of disturbances identified as a result of internal audits at Apipol-Farma

Years	Number of disturbances
2010	10
2011	7
2012	13
2013	9
2014	13

Source: own study based on documentation at PP-F Apipol-Farma Sp. z o.o.

To analyse the stability of the internal audit process, a control card was used in the alternative assessment of np. The value crossed out on the card is the number of disturbances in individual years. The card is built based on Bernoulli's and Poisson's system. The control limits were calculated using the following formulas:

$$\text{central line CL} = np, \text{ upper control limit UCL} = np + u_{\alpha} \sqrt{np(1-p)}, (1)$$

where:

n – sample quantity,

p – average value of the non-compliance fraction in the tested samples,

$\alpha = 0.01$  – significance level.

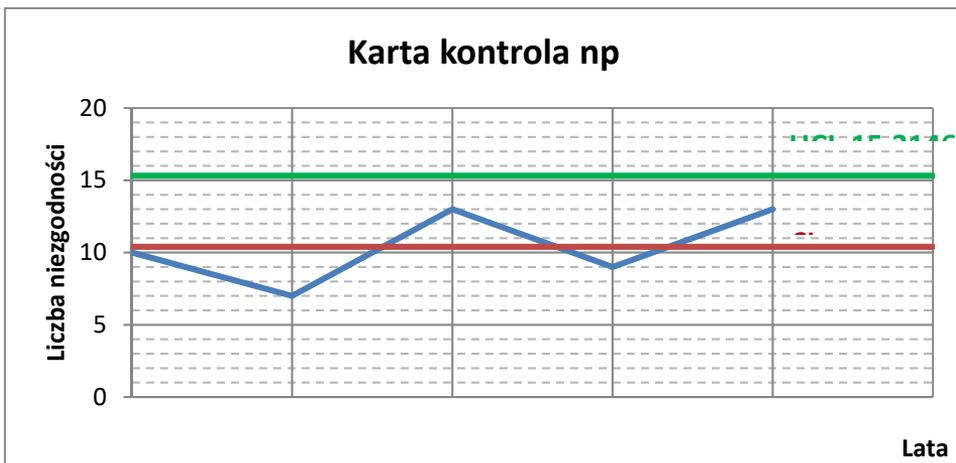
A list of specific control limits is presented in Table 2.

**Table 2.** A list of control limits of the np card

	np card
Upper control limit UCL	15.3146
Central line CL	10.4000

*Source: own study.*

Figure 12 shows the np control card for the internal audit process carried out in 2010-2014.



**Fig. 12.** The np control card for the internal auditing process carried out at *Apipol-Farma*

*Source: own study.*

The np card shows the influence of interfering factors, however, it does not cause any irregularities in the course of the process. All values are within the control limits. The process can be considered statistically regulated, which in the analysed period proceeds correctly.

## 11. Conclusion

Quality management is related to continuous improvement of an organization, and should be implemented based on an analysis of facts collected during direct research. Internal audits are an integral part of the quality management system and play an important role in the improvement of its actions. Moreover, it allows for a comprehensive, continuous inspection and assessment of implemented processes, which in turn leads to detection of non-compliance, wastage and high costs. Internal audit is an important tool in efficient organization management that allows for an effective assessment of the company's activities.

Based on the conducted research, it can be concluded that as a result of the internal audits implemented at PP-F. *Apipol-Farma Sp. z o.o.* in 2010-2014, in certain areas of the company's activities, the number of non-compliances in individual years showed a downward trend. The conducted Pareto-Lorenzo's analysis indicated the company's areas in which effective corrective and preventive actions should be taken. The statistical analysis of the internal audit process using the *np* card did not indicate irregularities in its course. All values were within the control limits. It should be acknowledged that the internal audit process in the analysed years was correct. As a result of the conducted internal audits, the organization implemented a number of corrective and preventive actions the effectiveness of which was assessed positively. Based on the review and analysis of literature and conducted empirical research, there is no reason to reject *the research hypothesis* formulated in the introduction: **Internal audit is an effective tool to assess and improve the quality management system and the company's functioning.** The theoretical concept of internal audit and the company's continuous improvement presented in the article along with the presentation of research results gives room to further considerations on this subject. Due to the fact that many non-compliances were repeated in the following years, research to determine the factors that could have influenced the identified problem should be undertaken. The organization should constantly strive for perfection. Each successive goal should motivate to the next, more difficult challenge, because only this attitude allows achieving success.

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# COMPARATIVE ANALYSIS OF THE LIFE CYCLE OF A PET BOTTLE AND A BIODEGRADABLE BOTTLE

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**Abstract:** Plastics are an inseparable element of modern human life. The amount of demand for plastics in Europe, it is growing steadily in 2016, it amounted to 49.9 million tons, of which as much as 39.9% of the volume of plastics produced went to the packaging sector. One of the most dynamically developing branches of materials are biodegradable plastics. Environmental pressure and the need to find alternative sources of raw material are the most important factors affecting the development of this sector.

In recent years. The phenomenon of biodegradable plastics lies in the fact that their main advantage is primarily the ability to undergo degradation in natural conditions. Degradation occurs with the help of living organisms, mainly bacteria, fungi, actinomyces, algae and protozoa, which treat biodegradable polymers as food. In addition to living organisms, natural factors contribute to biodegradation, especially UV radiation, oxygen and water. It is with the help of these factors that even 95% of organic matter can undergo decomposition. Biodegradable packaging, already in use, is characterized by durability equal to packaging from materials such as PH, PP, PS or PET.

**Keywords:** PET bottle, a bottle PLA LCA method, environment, emissions, carbon dioxide.

## 1. Introduction

Bearing in mind the rapidly progressing industrialization and the resulting degradation of the Earth's natural environment, more and more supporters gain the idea of sustainable development and pro-environmental consumption. They result in in-depth studies on the possible impact of human products – technical objects, and in particular machines and devices on the environment. At the same time, due to the growing interest in environmental issues, there is a need to evaluate the environmental impact of technological processes, for example by quantifying the environmental burdens they generate. Although the production process of PET bottles started in the mid-1970s, they appeared on the Polish market only at the turn of 1989/1990 along with economic changes and the

opening of the market. Currently, PET is the main packaging material used in the food industry for the production of various types of bottles, jars and containers. It is estimated that in 2016, the Polish plastics processing industry used approx. 3.3 million different polymer materials, which means an increase of approx. 6.9% compared to 2015. Demand for plastics in Europe in 2016 is estimated at about 50.5 million tons, which means an increase of 3.2 million tons compared to 2015. Opportunities and the potential of the industry in Poland illustrates the demand for plastics from plastics processing companies per conversion 1 inhabitant. It is currently around 85 kg, while the EU average is over 95 kg. The relation between the quantities of plastics processed into products and the generated waste amounts to about 3 million tons of processed plastics, which generate about 1.5 million tons of waste, 25% of which is recycled, and 19% is used for energy recovery [1].

The problem of improper use of plastic waste affects not only land but also the marine environment. The vast majority of waste in rivers and seas gets there due to inadequate waste management on land and people littering the environment. The huge garbage island, located in the north of the Pacific Northwest of Hawaii, is one of the most evident proofs of the destructive activity of man. It is estimated that at the moment it covers an area of about 1.6 million square kilometres, which is five times as much as the area of our country. The danger of plastics occurring in the aquatic environment is not only a long-term process of their decomposition, but above all a real threat to all living organisms.

For the sake of the natural environment it is recommended to adopt appropriate pro-environmental attitudes. From an ecological point of view, packaging should have, among others, the following features: minimizing the consumption of raw materials and energy during the production process; low level of water, soil and air pollution at the stage of the process of production, use and waste management; characterized by the lowest possible mass, because then they occupy less space during storage and transport; generate as little waste as possible (both by weight and by volume) and belong to the applicable organizational and legal system by using clear and unified ecological marks. World food corporations have long been interested in biodegradable plastics, noting in them the possibility of reducing CO<sub>2</sub> emissions and adjusting production to environmental standards. Among the many available materials, one should distinguish a biodegradable polymer obtained from vegetable pulp used for packaging production. Polylactic acid itself, polylactic acid, polylactic acid, PLA, is a biodegradable polymer obtained from corn. This is a biodegradable plastic in the natural environment and is absorbed by living organisms (bacteria), so it is an environmentally biodegradable biodegradable polymer. they need heat, bacteria and high humidity for decomposition, in which case the bottle and the label are decomposed into organic matter, water and carbon dioxide.

PLA bottles are produced in a technology similar to that for PET bottles. Preforms are produced from the polymer, which are then blown into bottles. For the production of preforms, the 24-socket HyPET 120 system is used, which produces preforms for 1 liter, 0.5 liter and 0.33 liter bottles. Blowing the bottles

is done on a 10-slot BLOMAX-10 machine. The bottles are biodegradable within 75-80 days under commercial composting conditions. The most environmentally friendly are biodegradable packaging produced from renewable natural resources annually, which after use can be recycled organically – composting.

The purpose of the work is to determine the impact of environmental damage resulting from selected production operations carried out for the process of shaping disposable bottles for beverages made of biodegradable and non-biodegradable plastics [2-4].

## 2. Methods

The concept of life cycle assessment was first introduced at the Society of Environmental and Chemical Sciences (SETAC) conference in Vermont in 1990. Thanks to the LCA assessment, there is a possibility to reduce environmental impacts at the design stage of a given product. Due to the assessment of all selected stages of the product's existence, it is possible to make comparisons that define different types of environmental hazards arising during the manufacture of a specific product. The ISO standards describe the requirements for conducting LCA analysis. Life cycle assessment refers to environmental aspects and potential impacts on the environment throughout the life of the product, from raw material extraction, through production, use, post-use processing, recycling, and final disposal. There are four stages of the life cycle assessment: goal definition and scope, collection analysis, impact assessment, interpretation. The first phase of LCA is to determine the purpose and scope of the research. The purpose of the research should clearly define the intended use, the reasons for the research and the recipient for whom the results are intended. The aim of the research determines the level of LCA detail and the scope of research is defined by unit processes, its boundaries and the functional unit. The functional unit is the smallest unit accepted for testing, which is the quantitative effect of the LCA system. Its main task is to establish a reference plane for normalizing the input and output data of a given system, which means that it should be precisely defined and measurable [5,6].

In the case of environmental impact assessment, 1000 units of 500 ml bottles were accepted as a functional unit. Analysis of the set in the life cycle consists in collecting data and selecting calculation procedures, defines the entry and exit for the tested product during its life cycle. As a boundary of the system, the consumption of raw material for the heating furnace and the preliminary blow process were assumed. Outside the system borders, there is a proper blow out, degassing and cooling of the bottle. The life cycle assessment is supported by specialized computer software. The article uses the SimaPro program, which allows using the IMPACT 2002+ index during environmental assessment [7].

### 3. Results and Discussion

Results of environmental damage burdens for the process of heating preforms made of PET and PLA are presented in table 1. When making a comparative analysis of environmental loads, it should be stated that a bottle made of non-biodegradable material causes twice as much environmental damage taking into account negative impacts on ecosystem quality, climate change, depletion of raw materials and human health.

**Table 1.** The results of the damage category

Damage categories	Unit	Heating of PLA preforms	Heating of PET preforms
Ecosystem quality	Pt	0,001138419	0,000172634
Climate change	Pt	0,000524541	0,001465995
Resources	Pt	0,000441035	0,002352974
Human health	Pt	0,000960264	0,00394323

*Source: own work.*

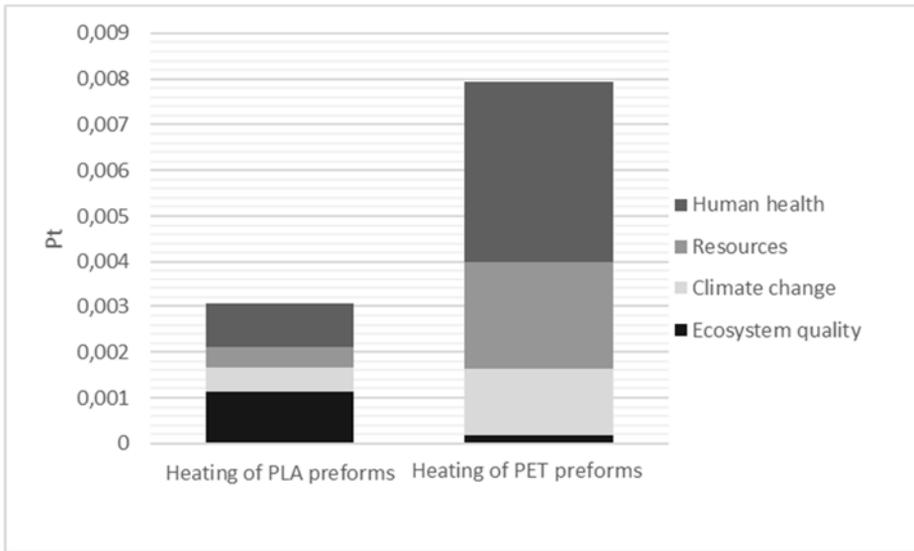
Results of environmental damage loads for the stretching proces and extension of preforms made of PET and PLA are presented in table 2. The result of the comparative analyzes is the statement with comparable environmental loads as a result of the stretching and heating process of the analyzed preforms.

**Table 2.** The results of the damage category

Damage categories	Unit	Stretching the preform PLA	Stretching the preform PET
Ecosystem quality	Pt	0,000824556	0,001155996
Climate change	Pt	0,000171777	6,4468E-05
Resources	Pt	0,000547814	0,00065242
Human health	Pt	0,000483941	0,000696379

*Source: own work.*

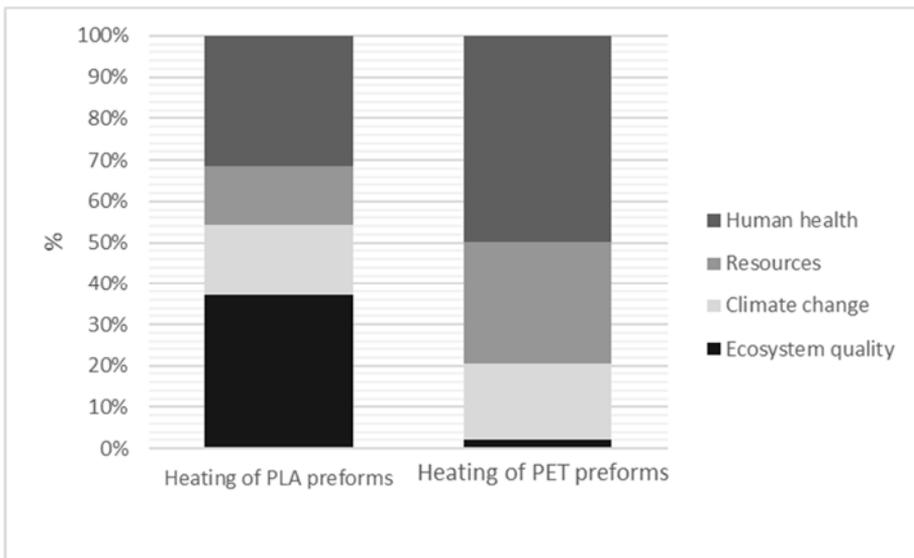
Figure 1 presents profiles of environmental influences for the process of heating the raw material. In the scope of these interactions, the dominance of the PET preform heating stage over the pre-heating stage of the PLA preform is visible. The main burdens are related to the depletion of fossil fuel resources, which have a significant impact on the depletion of raw materials. It is connected with acquiring energy resources from non-renewable sources. Environmental influences are mainly related to the acquisition of raw materials used for the production of fuels, mainly hard coal, which in Poland is the basis of the energy system.



**Fig. 1.** The results of the preform heating, Pt

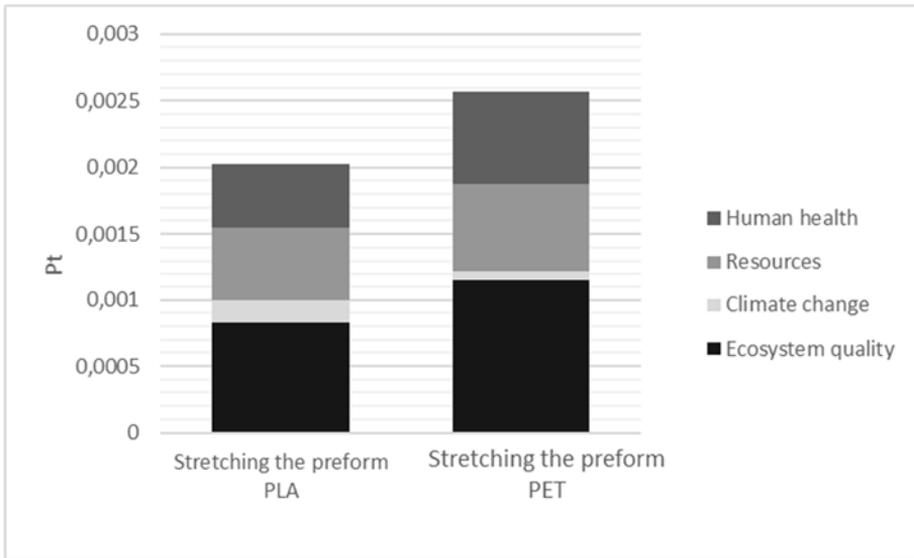
*Sources: own work.*

Figure 2 presents profiles of environmental impacts in percentage terms, from which it is clear that the non-biodegradable material applied, by as much as 20 percentage points outperforms biodegradable material in the category of human health. In addition, the associated impacts were also noted with depletion of fossil fuel resources.



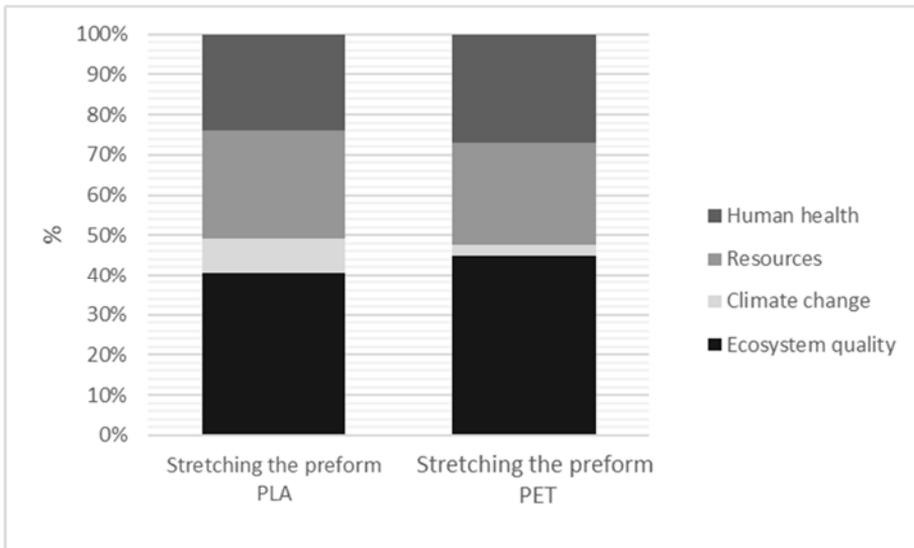
**Fig. 2.** The results of the preform heating, %

*Sources: own work.*



**Fig. 3.** The results of the preform stretching process, Pt

*Sources: own work.*



**Fig. 4.** The results of the preform stretching process, %

*Sources: own work.*

Figure 3 presents data on the stretching process and elongation of the PET and PLA preforms. Similarly to the analysis of the loads arising in the heating operation, a significant advantage of the associated environmental loads was found with depletion of resources and human health. This is just like in the previous case, related to obtaining fuels needed to generate electricity. A similar

result was also obtained for the category of impact of climate change, for which similar environmental points were obtained.

Figure 4 presents profiles of environmental impacts in percentage, for the stretching and elongation stage of the raw material, obtaining similar harmful values for both materials. Small differences result from the energy-consuming process. The similar amounts of electricity consumption recorded in the process determine the parameters of this operation.

#### 4. Summary

The main objective of the research was to determine the impact of environmental damage resulting from selected operations carried out for the process of shaping disposable bottles for beverages made of biodegradable and non-biodegradable plastics.

The most environmentally friendly was the operation of stretching and lengthening the preform made from the PLA preform. Nevertheless, the preforms made were also environmentally friendly from polyethylene terephthalate.

The presented results of analyses are only a part of research conducted on food industry facilities. The selected operations selected were selected to show the possibilities of environmental analysis of machines, processes and devices in food production.

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# INTELLIGENT ASPECTS OF PACKAGING IN FOOD INDUSTRY

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**Abstract:** The purpose of this article is to assess the perception of product packaging and to show the growing importance of modern – innovative and intelligent packaging in the food industry. Manufacturers try different ways to reach the consumer, mainly by changing the appearance of packaging or technological improvements that affect the quality of the product. The importance of the food industry is rising, causing a significant increase in competition. Manufacturers must therefore follow the changing trends and requirements of consumers so that the products offered by them are attractive in their eyes. The empirical part of the study refers to the results of an online survey that aimed at assessing the perception of packaging, on the example of Heinz ketchup packaging, familiarizing with consumers' opinions on intelligent packaging used in the food industry and proposing changes in the current product. After analysing the results of this research, it can be concluded that the functionality of the product is of the most importance for consumers. However, smart solutions are becoming more important; for example, they control certain parameters of packaged products.

**Keywords:** modern packaging, active packaging, trends, consumer.

## 1. Introduction

The food industry has undergone unimaginably dynamic changes over last 20 years. Through steady and constant development of technology, Poland has taken a high position among both innovative and modern European food producers. The food industry occupies a central place in the economy. Its purpose is to meet the basic needs of the population, which on the one hand are determined by the needs of the consumer, and on the other by the needs and abilities of agriculture [1]. The food industry is one of the most diversified and key sectors in the Polish economy, which is caused primarily by the financial turnover. Its diversity shows in the form of subsectors and entities (on the one hand fruit and vegetable processing, bakeries, tobacco industry, on the other hand, meat and dairy industry).

Producers of food products should be aware of the trends prevailing in the economy, because only then are they able to react quickly and adapt to the changes

occurring in it. The source of these transformations is the increase in the awareness of final consumers, who have much wider information about purchased consumer goods. Such information may be transferred via innovative/ intelligent packaging, which are described in detail in the further part of this study.

## 2. The role of packaging – modern trends on the market

The packaging industry systematically increases its share in the national economy and the packaging market itself plays an increasingly important role in general. Consumers meet with packaging every day. Changes of social conditions, market trends and expectations of producers and consumers cause that packaging to be constantly evolving. In addition, they perform new functions [2]. According to the sources, "as the civilizational, organizational and technical evolutions progress, the development of trade and food distribution, tightening of food safety requirements, as well as consumer awareness in the field of food safety and quality, the role of food packaging rises" [3]. Due to the fact that the packaging is something that the prospective buyer draws his first attention to, it should act convincingly on him and stay in harmony with the product.

Packages have different shapes, constructional forms, are made of various materials, have different durability. They also perform many different functions, among which the most important are: [4,5]

- production – size, type and shape of packaging very often affect the efficiency of work on production,
- marketing – the packaging can facilitate the sale of the product or at least provide the buyer with information about it,
- utility functions,
- logistics functions, which include:
  - protection (basic, should be fully adapted to the technical and functional characteristics of the product and to its "value"),
  - warehouse (related to the susceptibility of packaging to the processes of mechanization and automation, packaging should be adapted to the standardized dimensional system, to facilitate storage, formation of loading units, etc.),
  - transport (as above),
  - manipulation (as above),
  - information (the packaging should contain basic information about the product and information that determines efficient storage, handling and flow control, such as unit weight, number of products in the package, barcode, index),
  - rendering functions.

The basic task of packaging is to protect the product during transport, storage and sale, i.e. to protect the food product against pollution, damage or chemical reactions as well as climatic and biotic exposure. They give the customer an additional guarantee of the so-called first opening, and also restrict access by

unauthorized persons. Another equally important aspect is the distribution function that ensures efficient loading and unloading, placement and storage of products. With the development of new sales technologies, the importance of the information function has also increased, and the packaging itself is often referred to as the "silent seller". The complete knowledge about the product is provided by the information the packaging contains and the attention of the customer is attracted by such aspects as: shape, colour, patterns or the type of material from which it was made. The packaging becomes the carrier of the company's visual identification system and also shapes the image of the product, thanks to which it takes over the role of the seller during shopping, especially in self-service shops, which in turn affects the increase in sales [6].

Extending the shelf life of products has become a very important factor when planning the packaging production process. Actions were taken, thanks to which new types of packaging were generated – so-called active and intelligent packaging. New generation packaging affects the product, changes the conditions of food, and at the same time controls its quality.

Active packaging is usually seen in the form of small additives, sachets containing iron powder and calcium hydroxide. They are placed in packages or in the form of active ingredients added directly to the packaging, for example to packaging films [7]. These packages, unlike traditional ones, guarantee increased protection of the packed product. An example of an active packaging is shown in Figure 1 below.



**Fig. 1.** Example of active packaging

*Source: <http://www.intrapack.pl/>*

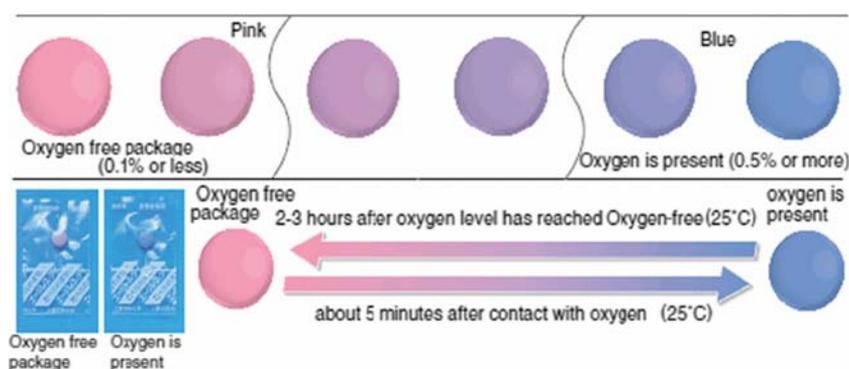
Intelligent packaging, on the other hand, makes it possible for example to analyse and indicate whether the temperature of the product you want to consume is appropriate. In Figure 2 it has been shown that by means of a reversible colour change it is possible to determine if the drink is chilled. After proper cooling of the can, the word "cold" or "very cold" will be readable (thanks to thermo-chrome labels).



**Fig. 2.** Intelligent beer packaging, indicating the right temperature for consumption

Source: <https://www.kierunekspozywczy.pl>

Active packaging also controls the qualitative and quantitative state of the atmosphere in its interior and with the help of special components it is able to remove unnecessary gases [8]. Another function is the ability to provide information about the oxygen percentage inside the package, i.e. ageless eye. Oxygen indicators inform about the atmosphere parameters and the tightness of the packaging (Figure 3).



**Fig. 3.** Ageless Eye Label

Source: [https://www.researchgate.net/publication/267695348\\_Intelligent\\_packaging\\_in\\_meat\\_industry\\_An\\_overview\\_of\\_existing\\_solutions/figures?lo=1sdddhbwsdxcbwdsdcjqwdjWSDBWND](https://www.researchgate.net/publication/267695348_Intelligent_packaging_in_meat_industry_An_overview_of_existing_solutions/figures?lo=1sdddhbwsdxcbwdsdcjqwdjWSDBWND)

External factors pose a threat to the produce, so oxygen scavengers have been created to protect it against spoilage, mould and loss of nutritional properties (Figure 4). Then the packaging itself can be described as a barrier that is delaying the adverse impact of the environment on the quality of packaged food. The current system of distribution of goods over long distances forces the necessity to

change the definition of packaging, enforces the necessity to extend the shelf life of food products, while maintaining their safety and quality [8].



**Fig. 4.** Oxygen absorbers in the packaging of biscuits

Source: <http://www.pochlaniaczetlenu.pl/images/blog/opakowanie-aktywne.png>

It is very important for consumers to easily check the expiry date of the product. An example of an innovative solution in this area can be a carton of milk, which, along with the expiration date of the packaged product, changes colour over time – from white to orange (Figure 5).



**Fig. 5.** Intelligent milk packaging, indicating the expiration date

Source: <https://i.pinimg.com/originals/5d/55/4b/5d554b0174a803b4ea6cfc7925f7fe3c.jpg>

The amount of packaging used by the public is constantly growing, generating an increase in the number of waste. This phenomenon compels the search for environmentally friendly materials from which the packaging can be made. First of all, these materials must be easily recyclable or destructible. Biodegradable packaging was created with this in mind and it also started the existence of the so-called pre-recycling. It can be interpreted as a "product without packaging" – that is, eliminating the process of waste creation.

Yet another example of innovation is the attempt to substitute packaged products with dispensers of produce, from which the customer packs the given goods to his own reusable containers. An example of such a solution can be found in the "Original Unverpackt" store in Berlin. Stationed there are distributors with dried fruits, nuts, vegetables, grains, as well as stainless steel containers with olive oil and balsamic vinegar. Customers put the necessary products into their own reusable packaging.

### **3. Results of the research**

For the purpose of this article a questionnaire was carried out, the purpose of which was to assess the perception of packaging, on the example of Heinz ketchup, to get acquainted with consumers' opinions on intelligent packaging used in the food industry, and to propose changes in the current product.

The questionnaire consisted of 7 questions. The study was attended by 100 people (40 women, 60 men). The vast majority of them, as much as 74%, come from the city, the remaining part from rural areas (26%). The age range of respondents is very diverse. The largest number of respondents (62%) is between 20 and 25 years old. The remaining part represents the ranges: 14-19 years (2% of respondents), 26-35 years (13% of respondents), 36-45 years (11%), 46-55 years (10%) and the last range are respondents over 55 (2% of the total).

The study used a convenient nonprobability selection method, using the online questionnaire. Links to the questionnaire were distributed via various forums and social networking sites, as well as sent via e-mail.

At the beginning of the questionnaire, the respondents were asked to provide information on their preferences related to the appearance of the packaging and the elements they pay attention to when purchasing the product. They were to answer the question: "What aspects of packaging do you pay the most attention to when buying the above product?" (Table 1). It was a multiple-choice question, which consisted of 4 responses imposed on the respondents and an additional open one in which it was possible to enter their proposals. The vast majority, as many as 53% of the respondents said that during the purchase of the product they pay attention to the functionality of the packaging. A little less, 50% chose the answer – size, proposed by a group of respondents.

**Table 1.** The distribution of answers to the question: "What aspects of packaging do you pay the most attention to when buying the above product?"

The distribution of responses to a multiple choice question	
Functionality	53%
The content of harmful substances in the packaging that negatively affect health	31%
Shape	30%
The material from which the packaging is made	27%
Other answers (additional suggestions)	
Size	50%
Taste	2%
Colour	1%
Tomato content	1%
Price	1%
I do not pay attention	1%

*Source: own work.*

Access to safe and nutritious food is of primary importance to the life and health of consumers. The knowledge on this subject is becoming more and more common, if only from the perspective of food market trends that are emerging. The quality of the entire product translates into consumer safety. There are many definitions of quality. One of the first was presented by C. Szczucki, who perceives the quality of food products as a degree of health, sensory attractiveness and availability under specific conditions of the technological process [9]. Food producers in order to provide consumers with access to high-quality products, should be oriented to their needs.

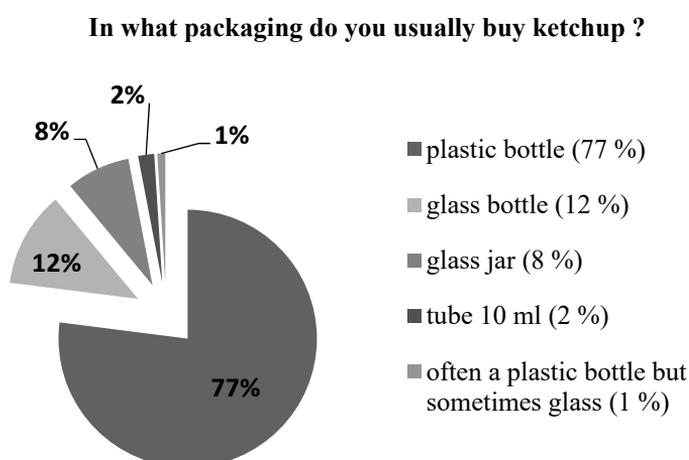
In the next question of questionnaire, respondents were asked to express their opinion on the functional flaws of the packaging (Table 2). Respondents indicated a cap that makes dosing of the product difficult as the most important factor interfering with everyday use of the product (64%). The second answer was the shape of the packaging, which in many cases is impractical.

**Table 2.** The distribution of answers to the question: "What interferes with your everyday use of the product?"

The distribution of responses to a multiple choice question	
Screw cap that hinders dispensing of the product	64%
Shape	27%
Lack of Durability	25%
Quality	25%
Size	20%
Other answers (additional suggestions)	
Sloppy and leaking packaging	2%
Sticker that needs to be removed before the first use	1%
When the packaging cannot be put with the cap down	1%
When ketchup is not getting out	1%
Nothing	1%

*Source: own work.*

Analysis of the answers received to the next question: "In what package do you usually buy ketchup?" (Figure 6) showed that as much as 77% of respondents choose ketchup in a "plastic bottle". The lowest value was given to the answer "often a plastic bottle, but sometimes a glass bottle" (1%), which was an additional answer proposed by the respondent.

**Fig. 6.** Chart – answer to the question from the questionnaire: "In what packaging do you usually buy ketchup?"

*Source: own work.*

In the next step the respondents had to answer an open question, which aim was to verify their knowledge of intelligent packaging: "What do you think are intelligent packaging?". An analysis of the answers provided showed that the vast majority of respondents (75%) did not understand the term "smart packaging". Among the correct answers were, for example:

- "Packaging that allows full use of the product, informing about the suitability of the product for consumption, while securing the product".
- "Such packaging has a shelf life mark for the product. With the approaching expiration date, they can change colour".
- "They allow to check the condition of a packaged product, thanks to the indicators placed on or in the packaging".
- "When on a beer bottle there is a special sticker that changes colour when the content has the optimal temperature for consumption (it is well chilled). The product could also change colour when it's out of date, because customers don't always look at the dates (it's often just trying without looking)".

The next question concerned the suggestions of classic, simple changes in the Heinz ketchup package (without any innovative improvements) – Table 3. Respondents considered as the most important the introduction of the applicator to packaging (57% of respondents). They also wrote their proposals for changes – among them: change of name, wider cap enabling the product to be put with the cap down. One person replied, that he did not know what changes he would like to introduce into the product, the other that he did not want to make changes because "it is easier to extract the content of the product from the plastic packaging rather than the glass one".

**Table 3.** The distribution of answers to the question: "What changes would you introduce in the current Heinz ketchup package? (Classic option)"

The distribution of responses to a multiple choice question	
Introduction of the applicator	57%
Adjusting the shape of the bottle to the hand	34%
Adding spouts to the bottle so that the bottle does not slip	25%
Switching to glass bottle	22%
Other answers (additional suggestions)	
Name	1%
None - it's easier to extract the product than from a glass bottle	1%
The wider cap allows the product to be put with the cap down	1%
Don't know	1%

*Source: own work.*

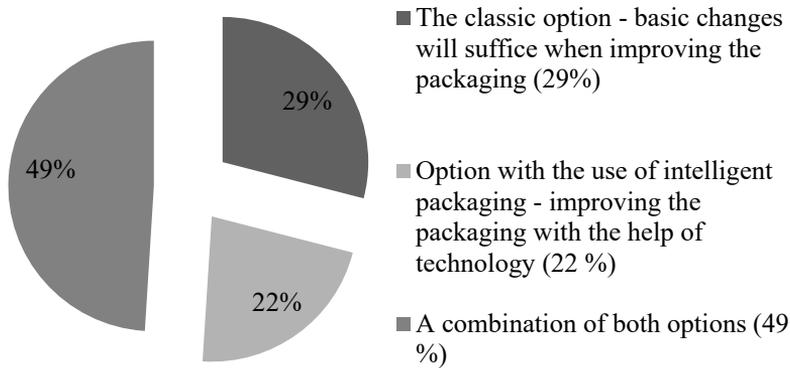
The survey also touched on the topic directly related to intelligent packaging. Possible answers to the question were formulated in a simple way, so that respondents could answer them without knowing the detailed characteristics of this type of packaging. Consumers were asked about beneficial changes in the Heinz ketchup packaging, taking into account the aspects of innovation, facilitating the use and storage of the food product (Table 4). Most respondents pointed to the technique of determining the freshness of a product based on a self-adhesive programmed label (51%). The least interesting was the answer: "Unintentional defrosting of the product indicator" (9%).

**Table 4.** The distribution of answers to the question: "Which of the options for changes related to the technology of intelligent packaging in your opinion could be used to improve the Heinz product?"

The distribution of responses to a multiple choice question	
The technique of determining the freshness of a product based on a self-adhesive programmed label	51%
Information about the right temperature for consumption	38%
Information on oxygen percentage inside packaging (like the ageless eye)	24%
None of the above	12%
Oxygen indicators (inform about the atmosphere parameters and the packaging tightness)	11%
Unintentional defrosting of the product indicator	9%

*Source: own work.*

Analysing the answers to the last question: "Which type of changes do you think is the better solution?" it can be noted that the majority of respondents chose the third option, a combination of both classical and innovative variants. This indicates the necessity of changes in the Heinz ketchup packaging, both simple ones (such as the shape of the packaging) and intelligent ones (like special labels informing about different parameters of the packaged product) – Figure 7.



**Fig. 7.** Chart with answers to the question: "Which type of change do you think is a better solution?"

*Source: own work.*

## 4. Conclusions

Packaging plays an increasingly important role on the global market. They contain all information about the product, and with their shape and graphic design they arouse interest encouraging sales. The current market situation in the field of packaging production is characterized by the pressure to improve their quality, while maintaining costs at a reasonable level. Trends related to ecology, marketing and design prevail, which means that due to the fast-growing packaging market, in the near future, manufacturers will fight more on packaging than on products. There is already a very fast pace of development of smart packaging, which informs consumers about, for example, the appropriate temperature of consumption or the ending date of suitability. Increasing the production of smart packaging will significantly reduce the level of discarded food. Therefore, there is a good chance that the problem of food waste will be reduced.

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# FOOD SAFETY IN THE SUPPLY CHAIN: THEORY AND PRACTICE

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**Abstract:** The presented article, which is comprised of an introduction, 5 sections, and a conclusion, concerns food safety in the supply chain. The first section, presents an analysis of threats that are closely linked to the functioning of the supply chain. The following two sections characterize organizational and legal requirements associated with food safety and quality management. The fourth section discusses the essence and working of traceability, which supports tracking, among others, the physical flow related to food. The final section presents selected issues (of which there are 9) important for the practice that need to be considered, according to experts, for the food supply chain to be properly monitored and managed, which means safe.

**Keywords:** supply chain, food, safety, factors, risk, threats, quality, management.

## 1. Introduction

Food safety in the supply chain is one of the key factors that in the near future, are going to be carefully examined and controlled. More and more often, there are reports of acts of terrorism that are beginning to have their source in food production.

Annually, in the United States, 5 thousand people die of foodborne diseases. In Poland, 80 thousand cases of foodborne illnesses are reported. In fact, there are many more. Food manufacturers – large and small – should be developing standards for safe food production, and in doing so, they should be able to get the support of public administration. Unless food industry organizations cooperate for the safety of food, consumers will be the victims of potential foodborne illnesses. Rather than plague companies with inspections (checks), the established supervisory authorities should work on what could be done to make production at specific food processing plants safer taking into account organizational, technical, and regulatory solutions<sup>1</sup>.

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<sup>1</sup> See *Musimy współpracować na rzecz bezpieczeństwa żywności*, [www.portalspozywczy.pl](http://www.portalspozywczy.pl), 27.10.2018.

## 2. The circumstances of food supply chain functioning

All activities in the supply chain, including the food supply chain, as regards both planning as well as reality, carry a latent risk that can be triggered by emerging threats (hazards) or disruptions.

The value of risk (its evaluation) in the supply chain can be expressed as<sup>2</sup>:

$$\text{risk} = f(\text{threat}, \text{vulnerability}, \text{consequences}) \quad (1)$$

or

$$\text{VaR} = P \times S_x \times P_d \times E_x \quad (2)$$

where:

$\text{VaR}$  – evaluation of risk,

$P$  – likelihood of risk occurrence,

$S_x$  – value of potential losses,

$P_d$  – risk vulnerability indicating the degree to which a given system (object) is vulnerable to threats and the level of potential consequences,

$E_x$  – exposure coefficient indicating the degree to which the supply chain is significant with regard to the actual occurrence of a threat.

For both formula (1) and (2), threats that have a great impact on the safety of the food supply chain are a crucial factor, and therefore, it is critical to predict their occurrence based on historical data, to detect (monitor) and identify them, to undertake adequate corrective actions.

Mathematical models allow a quantitative assessment of hazards, whereas heuristic techniques (including expert opinions) are instrumental in their qualitative analysis.

Extremely useful for the assessment of the 'capacity for damage' of threats to the food supply chain is their full identification by way of their division (classification) on the account of their duration, their physical properties, and their extent.

Threats to the functioning of the food supply chain may be divided into the following four groups:

The first group includes natural disasters and events caused by our civilization such as disasters, failures, and other events caused by human activity or human negligence. This group of threats includes fires, floods and flooding, strong winds and hurricanes, theft, outbreaks of human diseases, outbreaks of plant and animal diseases, radioactive and chemical contamination, and mining, construction, transport disasters, power outages.

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<sup>2</sup> See. P. Sienkiewicz, H. Świeboda, *Ryzyko w inżynierii systemów bezpieczeństwa*, [in:] *Inżynieria systemów bezpieczeństwa*, red. nauk. P. Sienkiewicz, PWN, Warszawa 2015, p. 41; P. Zaskórski, *Informacja ciągłości działania determinantą bezpieczeństwa organizacji*, [in:] *Nie-bezpieczny świat. Systemy. Informacja. Bezpieczeństwo*, AON, Warszawa 2015, p. 449.

The second group comprises events that disturb constitutional order of the state (states) such as terrorism, road blockages, illegal demonstrations, mass migration.

In the third group there are mechanisms that are aimed at destroying or distort information sent, transmitted, stored for purposes of logistic systems. Any information flow disruptions cause difficulties in efficient and effective management of logistic processes across the entire food supply chain.

The fourth group comprises threats that derive from economic crisis that really affects all without exception, logistic processes in the supply chain included. Not even a thriving economy is safeguarded against crisis and frankly, anti-crisis instruments have never been fully developed.

The aforementioned threats may have a destructive effect on the food supply chain disrupting the physical and information flow.

Disruptions, in the context of their impact on the functioning of the food supply chain, can also be grouped based on<sup>3</sup>:

- threat location – subsystem:
  - ✓ passageways of all modes of transportation (i.e. road, rail, air, water, sea),
  - ✓ modal points<sup>4</sup> of a logistic network frequently also called transport points (e.g. warehouses, individual container points, airports, logistic centers, etc.),
  - ✓ auxiliary devices facilitating road and transport points servicing,
  - ✓ management (e.g. lack of full identification of threats and their consequences, overestimating capacity, inaccurate interpretation of results, lack of optimization and simulation tools, failure to consider rising energy and transport costs, unexpected business failure of logistic services providers, failure to control employees who commit unethical acts by defrauding property or other malfeasance also during the selection of suppliers),
  - ✓ procurement (e.g. overlong, non-optimal and requiring too much management engagement tender and purchasing procedures, inconsistent supplier selection criteria, evaluation and selection of suppliers based solely on the lowest price criterion, delays in the purchasing process, poor quality, wrong price, wrong quantity, wrong stock, bribery, corruption, inability to procure appropriate packaging, lack of buffer stock),
  - ✓ production (e.g. malfunctioning of manufacturing systems, wrong raw materials, damage, shrinkage, theft of resources, unavailability of

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<sup>3</sup> See P. Sienkiewicz, *Teoria i inżynieria bezpieczeństwa systemów*, [in:] *Zeszyty Naukowe AON nr 1(66) 2007*, p. 254.

<sup>4</sup> Logistic network modal points (the most probable) are all points where products are stayed i.e. warehouses, transportation hubs and nodes, plants, distribution networks etc.

- competent personnel, production stoppages, failures, fires, floods, disasters, counterfeiting products, raw materials),
- ✓ distribution (e.g. failure to notice new products or new manufacturers, theft, weather conditions, poor quality of finished products, economic crisis, disregard for customer relations management, negligence in managing the flow of goods in the food supply chain),
- ✓ transport (e.g. food transported in inadequate conditions, disruptions caused by fires, explosions, transport accidents, washing cargo overboard, inability to move goods due to weather conditions, nonfunctional means of transport, inadequate internal transport, change in transport regulations, theft, disasters),
- ✓ inventory control (e.g. poor condition of warehouse infrastructure, lack of proper servicing and maintenance of measurement devices, theft, loss as a result of overstocking, fires, floods, structural disasters, power outages, computer system failures, automated identification system failures),
- ✓ packaging handling (e.g. product damage in transportation due to a wrong choice of packaging, delayed delivery of packaging due to adverse weather conditions, environmental pollution)
- ✓ customer order handling (e.g. disruptions caused by stock shortage, wrong orders and incorrect invoices, inability to locate products, delays, and also damaged goods delivered to customers, failure to respond to complaints and delays, fires, theft, damage),
- ✓ information (e.g. breach/loss of confidentiality, integrity and ability to dispose, natural hazards including fires, weather anomalies, electrostatics, passive and active attacks, random errors);
- duration:
  - ✓ brief, sporadic,
  - ✓ prolonged, intensifying
  - ✓ repeated, cyclical,
- physical properties:
  - ✓ material (e.g. introduction of a bioterrorism agent, poor quality of production, transportation or warehousing processes stemming from e.g. variability of quality systems across the same industry),
  - ✓ information (e.g. information technology system failures, automated identification system failures, inaccurate product information on product packaging),
  - ✓ energy (e.g. gas, fuel),
  - ✓ non-material (e.g. financial, political, social crisis),
- extent:
  - ✓ local, restricted to the logistics of a specific economic system which is e.g. a single, separate link in the supply chain,
  - ✓ extensive – across the entire supply chain – locally or globally,
  - ✓ widespread (e.g. as a result of shipments of contaminated food),

- ✓ contained (e.g. as a result of halted shipments of food for the mass market).

The classifications discussed above shows a broad and multifaceted spectrum of adverse activities that may affect food supply chain processes. From the vantage point of functions and levels of management, disruptions can arise from:

- fallacious premises for strategic planning, incorrect assessment for long term planning;
- tarnished reputation and image of a socially responsible organization due to incidents that provoke continual criticism from government agencies or international mass media;
- unsuitable or unreliable internal processes, production, warehousing and distribution technologies, hiring employees that have not undergone sufficient background check, seasonal workers national and foreign, malfunctioning process, shortage of workers;
- external, unpredictable actions of customers, suppliers, competitors, new market actors, substitutable services as well as changes in the external environment;
- poor relations with interested parties, and stemming from unsatisfactory assignment of authority and responsibility as a result of an inappropriate organizational structure, lack of or a flawed code of conduct for employees and managerial level employees;
- non-compliance with general legal regulations, internal rules and obligations under agreements;
- inadequate physical safety level of assets, processes and people (possibility of food contamination by production workers, including seasonal, defined as 'food terrorism');
- lack of a quality department and fully implemented standards for the management of food and food supply chain safety;
- unsatisfactory or unfit telecommunication resources (outdated information technology, inconsistent information and communications strategy, disruptions in the operation of information and communications infrastructure); impact on the natural environment – permanent, major damage to the environment, loss of commercial, recreational or conservation utility resulting in considerable financial consequences for the participants in the food supply chain.

### **3. Organizational and regulatory requirements for the supply chain safety and security**

Dependability of logistic processes, both upstream and downstream, is not only an area of interest for its participants; it is also a matter of particular concern as regards the efficiency and effectiveness of its management. Supply chain

safety, along with food supply, includes 'end-to-end' safety which involves, among others<sup>5</sup>:

- improvement of the level of safety of the supply chain (focusing on creating conditions that ensure unimpeded flow of goods, including food products);
- implementing safety certificates taking existing systems into account;
- common safety assessment suitable for all modes of transport in an effort for international cooperation in the fight against terrorism and other criminal activities such as piracy.

It must be allowed that a modern, innovative approach to management in the context of relationships that derive from the safety of the supply chain, including food supply, makes it possible to create a synergy effect.

Useful in this respect are analyses and considerations based on regulatory, organizational, and technical requirements. These certainly include international requirements and standards, especially the following representative five.

**The first.** In 2008, ISO 28000: 2007 – *Specification for security management systems for the supply chain* international standard was introduced that is applicable to all organizations who play a role in the supply chain at any of its stages starting from the selection of contractors to transport, freight, customs, storage, etc.

A paramount objective of the system of security management for the supply chain according to ISO 28000 is the assurance of an appropriate level of security by implementing and maintaining security measures by all participants in the supply chain so as to assure the security of the entire chain. The chain is only as strong as its weakest link<sup>6</sup>. The most significant benefits of implementing and operating a security management system for the supply chain as specified in ISO 28000: 2007 include<sup>7</sup>: raising awareness of risk related to individual phases of logistic processes by the identification of threats and assessment of the likelihood and the consequences of their occurrence; increasing the dependability of the supply continuity by establishing preventive procedures for specific threats, which impacts on the increase of the dependability of deliveries in the supply chain, and as a result, on customer satisfaction; optimization of the supply chain processes by establishing procedures that facilitate accomplishment of objectives not only under normal, non-aberrant conditions.

**The second.** In May of 2012, an international standard ISO 22301 was published that specified requirements for business continuity management systems. It replaced the British standard BS 25999. Based on its predecessor, the norm introduced new requirements that have a favourable effect on the entire business continuity management system. The differences are immediately obvious once the structure of the standard is considered. The requirements specified in ISO

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<sup>5</sup> *The White Paper Roadmap to a Single European Transport Area – Towards a Competitive and Resource Efficient Transport System, European Commission 2011, COM(2011) 144, final version, Brussels, 28.03.2011, p. 41.*

<sup>6</sup> See A. Szymonik, *Eurologistyka Teoria i Praktyka*, Difin, Warszawa 2013, p. 137.

<sup>7</sup> See *ISO 28000 Bezpieczeństwo w łańcuchu dostaw*, <http://www.lrqqa.pl/> 01.11.2018.

22301 are presented in ten chapters whereas the British predecessor had 6 of them. The standard includes<sup>8</sup>:

- a new formal requirement for the organization to determine its context in order to gather all information necessary to establish a Business Continuity Management System suitable for the organization and supporting its operations and objectives (in identifying organizational context, the organization should identify and document the scope of its operations including products, services, place in the supply chain, relationships with customers and suppliers, relations between its business continuity policy and other applicable policies, statutory and other regulatory requirements);
- specific requirements for top management (the standard requires top management to be actively engaged in the implementation of the business continuity policy and in the establishment its objectives; moreover, top management should demonstrate its commitment in the establishment, implementation, and monitoring the business continuity management system);
- requirements related to the establishment and implementation of procedures for internal communication (with employees), external communication (with customers, partners, local community, and media), and communication in crisis situations that takes into account notifying appropriate authorities;
- specific requirements for the implementation and coordination of the business continuity management system including impact analysis, analysis of risks, strategy and procedures for business continuity management and rules for its testing (specifies requirements for disruptive incidents, e.g. it requires that procedures for incident detection and monitoring, for communication of information about incidents during their entire life cycle, and for documenting decisions during disruptive incidents be established);
- a requirement for establishing documented procedures for restoring and return to normal business activities once a disruptive incident has been contained;
- requirements for internal audits, performance reviews, and specifications related to monitoring, measurements, analysis and evaluation of the efficiency and effectiveness of the business continuity management system;
- establishing measurable objectives and measures for the evaluation of their achievement (the organization should determine what should be monitored and measured, define methods of monitoring, measurement, analysis, and evaluation, and indicate when the measurements are to be performed and analyzed).

**The third.** The International Ship and Port Facility Security Code (ISPS) defines a framework for cooperation of ships and port facilities to detect activities that may pose a security threat and to prevent them. The International Ship and

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<sup>8</sup> See *System Zarządzania Ciągłością Działania – ISO 22301:2012*, [in: <http://www.iso.org.pl/>, 18.07.2018.

Port Facility Security Code applies to<sup>9</sup>: all passenger ships, cargo ships of 500 gross tonnage and upwards; mobile offshore drilling units; port facilities servicing ships on international voyages.

The plan needs to include<sup>10</sup>: specification of actions to prevent the carriage of weapons and other dangerous objects illegally aboard the ship; specification of restricted areas and measures to prevent unauthorised entry; measures to prevent unauthorised embarkation; procedures for response actions to ship security threats; procedures for operation at different security levels; assignment of responsibilities for complying with the provisions of the plan (security officer in the company, ship security officer); procedures for ensuring the ship and crew's preparedness for action under threat (crew training, equipment maintenance).

The ISPS facilitates threat detection and prevention within international cooperation, establishes the assignment of roles and responsibilities, expedites collection and exchange of information related to security protection, provides methods of security assessment, ensures appropriate security standards.

It requires ship crews and port facility employees<sup>11</sup>: to gather and assess acquired information, implement and maintain communication standards; to prevent unauthorised entry and embarkation, carriage of weapons, etc.; to start alarm procedures; to develop ship security plans and port facility security plans, and to document training programmes and exercises.

The Code specifies three security levels<sup>12</sup>. Level 1 means normal conditions where standard procedures are sufficient for assuring security. Level 2 is when there is heightened risk, which means that additional measures should be implemented (Level 2 should be maintained for a limited time until the threat ceases or mitigating action is taken). The third level is implemented when there is a probable or imminent risk of a security incident (e.g. information about a planned attack or an explosive device has been received, and during hostilities).

**The fourth.** *Advanced Cargo Information (ACI)* enables<sup>13</sup>: data sets of information on a logistic entity (the ship – its name, voyage number, port of discharge, destination; the cargo – names of goods, quantity, weight; exporter/importer – name, address; container – its number, type; bill of lading – number) to be provided in an electronic form well in advance of the cargo arrival in the importing state; authorised parties at any location to have access to current

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<sup>9</sup> See *Międzynarodowy Kodeks Ochrony Statku i Obiektu Portowego*, [at:] <http://www.gospodarkamorska.pl/>, 30.08.2018.

<sup>10</sup> See M. Forkiewicz, *Przedsiębiorstwo ochrony w portach morskich*, [at:] <http://www.ptzp.org.pl/>, 07.07.2018.

<sup>11</sup> See K. Mrowiec, *Ochrona portów i obiektów portowych*, [at:] <http://www.moje-morze.pl/pm1.html>, 07.07.2018.

<sup>12</sup> See A. Królikowski, T. Stupak, R. Wawruch, *Zasady oceny ryzyka stwarzanego przez farmy elektrowni wiatrowych na morzu*, [at:] <http://www.czasopismologistyka.pl/>, 30.07.2018.

<sup>13</sup> See *Zaawansowane Informacje o Ładunku (ACI)*, [at:] <http://www.sgs.pl/pl-PL/Logistics/Transp>, 02.08.2018.

information via an online application; processing of importation/exportation documentation at due time and close monitoring of the movement of goods.

ACI is not mandatory for the exporter or the importer but it is firmly based on the data that the exporter declares in the bill of lading. The information contained in the bill of lading must be identical with the information given by the ship operator/carrier in ACI. Should any differences arise or inaccurate information be provided by the exporter, any problems/costs that arise in Canada or the USA during customs clearance processing will be charged to the exporter. Therefore, when shipping goods to these countries, exporters should exercise particular diligence when declaring specific values, e.g. the number of goods units, gross weight, and choose tried and trusted logistics operators to carry their cargo<sup>14</sup>.

**The fifth.** Guidance on social responsibility – ISO 26000: 2010, an international standard (developed by the joint efforts of 99 countries) that provides guidance on corporate social responsibility i.e. the responsibility that rests with the organization for the impact that its decisions and actions have on the society and the environment and that it fulfills by transparent and ethical conduct<sup>15</sup> that contributes to sustainable development including the health and well-being of the society; respects stakeholder expectations (people or groups that have an interest in the organization's decisions or actions); complies with the law and is consistent with international norms of behaviour; is integrated into the organization's activities and practised in its relations across the sphere of its influence (fair operating practices).

The norm is intended to standardize our understanding of *corporate social responsibility* (CSR).

ISO 26000 aims to provide support for organizations in their contribution to sustainable development. The standard is to encourage them to go beyond regulatory requirements while acknowledging that abiding by the law is a fundamental duty and an indispensable part of its social responsibility. The norm is to promote a general understanding of social responsibility and supplement rather than replace other instruments and initiatives to this end. When implementing ISO 26000 it is worth keeping social, environmental, legal, cultural, organizational, and economic differences in view while at the same time, respecting international norms of conduct.

#### 4. Selected standards for food safety and quality management

The European Union strategy for food safety rests on three pillars. They are: the law, advisory guidance based on research and practices, and control and implementation. Legislation concerning food safety in the EU is all-

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<sup>14</sup> See ACI – *Advanced Commercial Information – w eksporcie do Kanady*, [at:] <http://www.open-sped.pl/eksport/>, 17.08.2018.

<sup>15</sup> *ISO 26000 Guidance on social responsibility*, [at:] <http://www.pkn.pl/>, 20.07.2018.

encompassing; it regulates: foodstuffs hygiene, hygiene of foodstuffs of animal origin, official inspections performed to verify compliance with food and feed law and regulations for animal health and welfare.

Assuring food safety is associated with the implementation of food safety management systems including among others: principles of Good Hygiene Practice – GHP, Good Manufacturing Practice – GMP, and the HACCP system. It is a statutory requirement laid down among others in<sup>16</sup>: the statutory act of August 25th, 2006 on the safety of food and nutrition; 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.

In the light of the latter act of law, all food business operators regardless of the size and profile of their business operations are required to have an implemented and functioning HACCP system as of January 1st, 2006. The abbreviation HACCP stands for *Hazard Analysis and Critical Control Point System*. HACCP is an instrument for food safety management and a universal method for systematic assessment of the possibility of hazards, and for determining methods of their elimination during food manufacturing.

In practice, there are also other standards for food safety including the following:

*The International Food Standard (IFS)* – an international food safety standard developed in 2002 by representatives of German retailers. In 2012, a revised and updated version of the standard was published - IFS Food version 6 effective of July 1st, 2012. The IFS System is a specific standard developed for and recognized by all food manufacturers, primarily to meet the requirements of retail chains and their private label brands (store brands). The overarching goal of the system is the assurance of the safety and quality of products and their compliance with applicable laws and norms. The IFS unifies requirements and provides for transparency in the supply chain from the raw material through to the final product<sup>17</sup>.

The BRC Global Standard was developed by the *British Retail Consortium* and is required by a growing number of hyper and supermarkets across Europe. The standard aims to assure the highest quality of supplied products. The primary advantages of the BRC Global Standard implementation are<sup>18</sup>: a reduction of the number of products of inadequate quality; control over the supplier as well as the recipient; a reduction of the number of audits performed by recipients; standardization of food safety requirements; systematic documentation of food

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<sup>16</sup> See *HACCAP*, [at:] <http://www.izz.waw.pl/>, 12.06.2018.

<sup>17</sup> See *IFS*, [at:] <http://www.suedzucker.pl/pl/>, 12.06.2018, *IFS – Lista wymagań audytowych*, Hamilton Poland LTD, Rzeczoznawstwo i badania laboratoryjne, materiały szkoleniowe, Toruń 2012.

<sup>18</sup> See *Globalna norma bezpieczeństwa żywności*, BRC Global Standard, British Retail Consortium, London 2015.

product quality compliance. In January 2015, the seventh version of the standard was published effective of July 1st, 2015.

Not without significance for the management of food safety and hygiene is ISO 22000: 2006 which introduces a unified and globally harmonized standard for food safety and hygiene at the same time facilitating the implementation of the HACCP system and integration with ISO 9001: 2008.

ISO 22000: 2006 may be implemented by all organizations directly or indirectly involved in the food supply chain, i.e. producers and manufacturers of food, feed, grains, and food additives, farmers, food service companies, retailers and wholesalers, cleaning and sanitation services companies, transportation companies, distributors, suppliers of equipment, cleaning and sanitizing agents, packaging materials and other food contact materials.

Management of food safety and quality in line with ISO 22000 must meet certain requirements for food safety related to<sup>19</sup>:

- communication in the supply chain – internal and with suppliers and customers to ensure identification and monitoring of safety hazards;
- quality management system – implemented and updated system should be integrated into general activities related to organizational management;
- monitoring operational prerequisite programmes for materials management (e.g. raw materials, chemical agents), measures preventing cross contamination, pest control, personnel hygiene, utilities, waste disposal;
- verification of HACCP principles – with an emphasis on analysis and monitoring of hazard control measures as a key to effective performance of the system.

Additionally, the following standards have been developed for logistics<sup>20</sup>:

- IFS Logistics – is a standard for organizations that have physical contact with packaged food products (transportation, bulk breaking of packaged food products, loading, unloading, storage, distribution, pallet storage). The standard applies to road, rail, sea transport, and to freezing and cooling processes.
- the BRC Global Standard Storage and Distribution is applicable to warehousing and distribution. It sets requirements for logistic processes in the supply chain that include: warehousing, distribution, transportation, contractual services, packing, cooling, freezing, defrosting.
- BRC/IoP<sup>21</sup> Packaging and Packaging Materials – specifies requirements related to hygiene practices, production environment, and packaging inspection. The standard includes requirements not only for materials for food packaging but also for manufacturers of any other packaging (e.g. glass,

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<sup>19</sup> See A. Kielesińska, *Aspekty prawne bezpieczeństwa żywności w logistyce*, [at:] Logistyka 6/2014, s. 13454.

<sup>20</sup> See *Systemy zarządzania bezpieczeństwem żywności*, Dekra, [at:] <http://www.dekra-certification.com.pl/>, 11.10.2018.

<sup>21</sup> IoP (Institute of Packaging) – Instytut Opakowań.

plastic, wood, paper, aluminum, steel). The standard defines two levels of hygiene risk that depend on the end-use of packaging. Packaging that comes into direct contact with food products will have the highest level of risk, whereas packaging for non-food consumer products will have the lowest.

- IFS Broker – provides standards for the quality and safety of products during their purchase, storage, and re-sale by importers, brokers, and trade agents. Therefore, it is used by trade agents, importers, brokers, and other organizations that deal with the trade of food products.

The benefits of food safety management system certification are the following<sup>22</sup>: confirmation that legal requirements are met and that food hygiene and safety standards, including HACCP, are implemented; increased level of safety of food products on the market; enhanced consumer trust in the organization; facilitated cooperation with partners in the supply chain.

Of fundamental importance for food safety in American legislation is the *Food Safety Modernization Act* (FSMA) signed into law on January 4th, 2011. The document is the furthest reaching reform of legislature concerning food safety implemented in the last 70 years. The primary objective of its enactment was the will to provide a higher level of food safety for consumers by shifting from the previous FDA standard procedures that relied on responding to contamination that had already occurred, and replace them with adequate preventive mechanisms to preclude it<sup>23</sup>.

The government of Poland are planning to establish a single State Inspectorate for Food Safety instead of several specialized institutions. Meantime, many veterinarians have been critical of the draft act on the establishment of a super-inspectorate that will impede performance of tasks related to food safety. Currently, food control is carried out by the State Sanitary Inspectorate, the Agricultural and Food Quality Inspection, the Polish Trade Inspection, and the State Plant Health and Seed Inspection<sup>24</sup>.

Doubtless, the *European Food Safety Authority* (EFSA), which is a key authority of the European Union established pursuant to the Regulation (EC) No 178/2002 of the European Parliament and of the Council of 28 January 2002 to undertake action related to risk assessment, requires mention. The Authority, funded from the EU budget, operates independently of the European Commission, the European Parliament, and the Member States. Its mission is to provide scientific opinions and advice to support EU legislation and policies in all fields which have a direct or indirect impact on food and feed safety as well as on related issues in the area of animal health and welfare and plant health. The Advisory Forum of the European Food Safety Authority serves the purpose of cooperation

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<sup>22</sup> See PN-EN ISO 22000 – System zarządzania bezpieczeństwem żywności (HACCP), Urząd Dozoru Technicznego, [at:] <http://www.udt.gov.pl/>, 08.10.2018.

<sup>23</sup> [www.wetgiw.gov.pl](http://www.wetgiw.gov.pl), 15.10.2018.

<sup>24</sup> *Powstanie Państwowej Inspekcji Bezpieczeństwa Żywności przesądzone*, [www.polskieradio.pl](http://www.polskieradio.pl), 15.10.2018.

with the competent national food safety bodies in the EU Member States. The Forum is comprised of representatives of all Member States, and it provides a platform for an exchange of information and cooperation between the EFSA and the competent bodies in the Member States<sup>25</sup>.

Compliance with procedures established in regulatory acts, other standards and norms would not be possible without a rapid alert system for the notification of direct or indirect risks to human health derived from food or feed; risk assessment (construed of as a science-based process consisting of four stages: risk identification, risk analysis, risk evaluation and assessment), and risk management; crisis management in situations caused by biological, chemical or physical hazards to food or feed or a condition of food or feed that could have a negative impact on human health.

## 5. Traceability as a food safety management support tool

Food and its packaging, as any product, should satisfy the needs of manufacturers, logisticians, and consumers by meeting certain specifications: physical (e.g. dimensions, weight that facilitate transport and warehousing), chemical (e.g. composition of raw materials and their effect on the body, packaging, and environment), technological (e.g. ease of processing, storage), organoleptic (e.g. pleasant sensory feelings – tactile, gustatory, olfactory), functional (e.g. ease of opening, preparation, utilization, traceability), economic (price, cost of preparation, utilization, transport), aesthetic (e.g. colour, shape), safety (e.g. harmfulness, healthfulness, facility of monitoring the quality of a product, anti-theft or damage protection, vulnerability to contamination).

All of the presented requirements are important, however, those that have an effect on human health, life, and the natural environment are particularly consequential. As evidenced in real life, products that should never be marketed unfortunately, sometimes are. Below follow a few examples:

The first. In 2016, in Sweden, 19 tonnes of Polish apples were withdrawn from the market. The reason – the level of residue chemicals used for spraying apple trees was found to exceed the maximum permissible level eight-times in the apples. The Swedish National Food Agency reported the situation to the European Commission. Allowedly, having supported the Western World in imposing sanctions against Russia, Poland has lost a large and promising Russian market for its agricultural products including apples. And even though the Polish government is satisfied with the rate at which the loss is being made up for – from Africa to Asia, producers and vendors know all too well that finding new markets and building a reputation of a reliable supplier are no mean feat and require time<sup>26</sup>.

The second. In 2017, in Germany, insecticide contamination of eggs was discovered. From the Netherlands and Belgium to Germany, more than 10 million

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<sup>25</sup> *Europejski Urząd ds. Bezpieczeństwa Żywności*, [www.gis.gov.pl](http://www.gis.gov.pl), 03.10.2018.

<sup>26</sup> *Szwecja wycofała 19 ton polskich jabłek*, [www.wolnemedi.net](http://www.wolnemedi.net), 15.10.2017.

contaminated eggs were imported altogether. Higher doses of an insecticide known as fipronil may lead to liver, pancreas, and kidney failure. The contaminated eggs were withdrawn from the German market and destroyed. The World Health Organization (WHO) classifies the compound as 'moderately toxic'. In the European Union, fipronil is forbidden from use in animals that are intended for human consumption<sup>27</sup>.

The third, in Germany where an unknown extortionist demanded 10 million euro from retail networks lest s/he should plant contaminated food products in supermarkets across Germany and other countries. The offender or offenders warned in an email sent to the police, retail companies, and consumer organizations that starting from September 16th, 2017 20 poisoned food products would be placed in stores, unless they were paid several million euro. The extortionist did not specify what products would be placed in what regions or stores. S/he proclaimed that s/he intended to strike German food companies across the country. To prove his/her determination, shortly before closing on Saturday, September 16th, the offender placed 5 poisoned food products in a store in Friedrichshafen in Baden-Württemberg. The extortionist informed the police, which allowed them to remove the products promptly. The poison used by the extortionist belonged to the class of glycols. No further details were provided for the sake of the investigation. In all likelihood everything ended well, which is good. Should things have gone a different way, the consequences could have been catastrophic<sup>28</sup>.

Based on the presented examples, it may be concluded that if we know precisely where raw materials come from, who ships and stores them, where they are used in production, and who the distributor is, we are able to reduce the number of counterfeit, unsafe products reaching the customer with the caveat that an adequate and safe system be built throughout all stages of production, processing, and distribution to enable quick identification of suppliers and direct customers. Helpful in this regard is a system known as traceability.

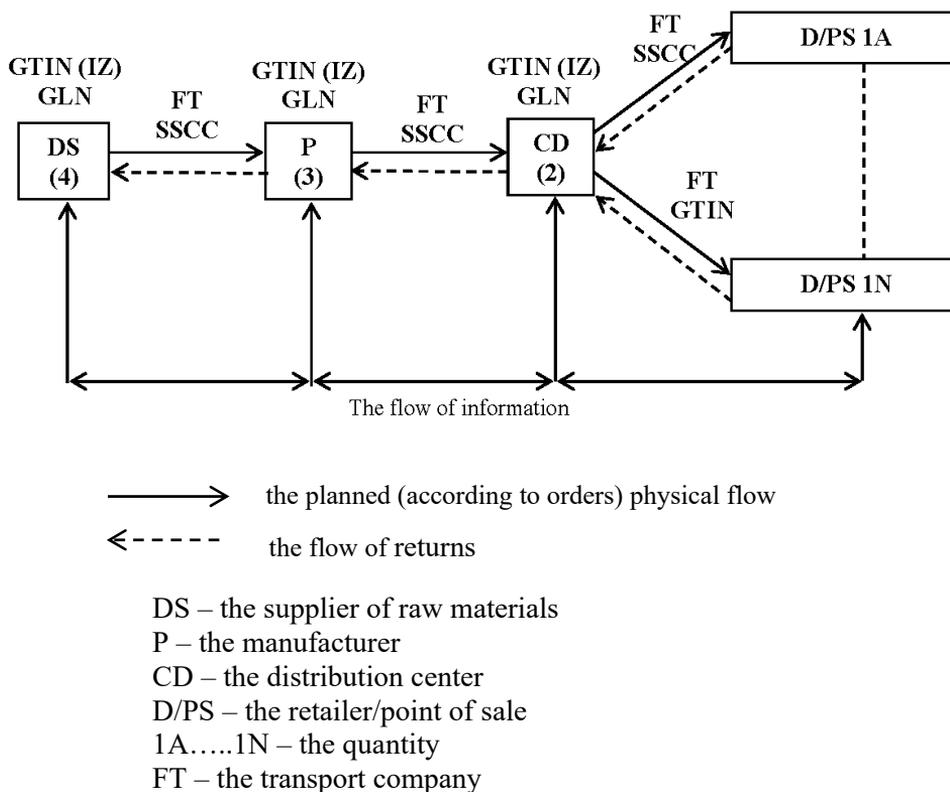
## 6. The essence of traceability

Traceability, otherwise called the TTC (*Track, Trace and Control*), enables: tracking the path of the product from the moment of its manufacture from raw materials until it reaches the end customer in the supply chain; recording parameters identifying the goods and mapping their flow.

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<sup>27</sup> *Skażenie milionów jaj środkiem owadobójczym*, [www.polsatnews.pl](http://www.polsatnews.pl), 15.10.2017.

<sup>28</sup> *Niemcy: szantażysta grozi zatruciem żywności w supermarketach*, <http://wiadomosci.onet.pl/>, 28.09.2017.



**Fig. 1.** Traceability system in operation

*Source: authors' analysis.*

Traceability enables precise identification of processes in the physical flow in the supply chain provided that all its participants follow the same rules and norms, e.g. GS1 standards, and EU regulations.

Principal GS1 standards include: identification of trade items (goods) – GTIN (GTIN-8, GTIN-12, GTIN-13, GTIN-14); identification of logistic units – SSCC; physical location identification – GLN; description of standards, bar codes, EPC, eCom electronic communication, and others.

The standards listed above define and ensure that<sup>29</sup> all traced goods or cargo are identifiable thanks to the use of standardized identifiers; an identification stays on the goods/cargo until tracking is complete; all locations are identified with a unique GLN number in the entire supply chain; data on products and their physical flow are collected and shared as agreed on by trade partners (e.g. GDSN, EDI, online EPCIS solutions).

Figure 1 presents a traceability system in operation.

<sup>29</sup> *Kody kreskowe i inne globalne standardy w biznesie*, scientific editor E. Hałas, ILiM, Poznań 2012, p. 337.

The core elements of the model are: retailers – points of sale (1A...1N); a distribution center (2); a manufacturer (3); a raw materials provider (4); transportation companies (FT) that physically deliver raw materials and products to recipients; information system to enable the flow of information.

If the system operates without disruption, the physical flow proceeds according to orders placed in the following order: by retailers/points of sale (1A...1N) with the distribution center (2), the distribution center with the manufacturer (3), and the manufacturer with the raw materials provider (4).

Whenever any problems arise related to the quality of the product, previously established procedures are triggered that enable quick action to eliminate the disruption. Because applicable standards and information technology are used, the following actions are undertaken should the end-user receive a defective product<sup>30</sup>:

- the retailer – point of sale (1A):
  - ✓ identifies the name of the defective product, its number (GTIN), supplier (GLN), lot number (IZ 10),
  - ✓ notifies the product distributor (2),
  - ✓ withholds all products of the identified lot from further sale;
- the distribution center (2):
  - ✓ identifies all products (GTIN) of the defective lot in its possession (IZ 10),
  - ✓ notifies the supplier of the defective lot (GLN),
  - ✓ notifies the recipients (GLN) of the defective lot (SSCC, IZ 10),
  - ✓ withholds the defective lot of products from further distribution;
- the manufacturer (3):
  - ✓ identifies the raw materials related to the anomalies and identifies their supplier (GLN),
  - ✓ notifies the supplier of the problem,
  - ✓ withholds the product lots manufactured with the identified raw materials that have not yet been dispatched from further sale,
  - ✓ notifies the recipients (GLN) to whom defective product lots have been dispatched (SSCC, IZ 10);
- the supplier of raw materials (4):
  - ✓ analyses what could have caused the problem – identifies and confirms the cause,
  - ✓ notifies all recipients (GLN) of the cause of the problem and discloses the lot number of the raw materials (IZ 10),
  - ✓ identifies all dispatched materials from these lots (SSCC),
  - ✓ withholds the remaining raw materials in these lots from further use.

Moreover:

- the manufacturer (3) – in addition, based on historical data:

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<sup>30</sup> G. Sokołowski, *Traceability – bezpieczeństwo i śledzenie przepływu produktów w łańcuchach dostaw, w oparciu o standardy GSI i wymagania UE*, ILiM, Poznań 2014, materiały z Webinar – 6.01.2014.

- ✓ searches for defective product lots previously manufactured;
- ✓ identifies SSCC numbers of boxes and pallets containing product lots that should be withdrawn/recalled,
- ✓ identifies the recipients (distribution center (3)) of defective products (GLN) and provides them with information concerning the products that are to be returned (SSCC, GTIN, IZ 10);
- the distribution center – based on additional information provided by the manufacturer (3):
  - ✓ identifies boxes and pallets (GTIN, SSCC) that are to be returned,
  - ✓ removes and returns the defective products from the distribution centers (GTIN, SSCC),
  - ✓ provides retailers and points of sale (1A...1N) SSCC and/or GTIN numbers and numbers of dispatched lots that are to be removed;
- the retailer – point of sale (1A...1N):
  - ✓ retailers identify suspect products (based on the GTIN, IZ 10 lot numbers) and return them to the supplier – distribution center (2).

More and more frequently, traceability is also used by manufacturers in the OEM sector<sup>31</sup>, automotive industry (e.g. identification of parts/components used in the automotive industry – operated by GS1 Germany), finance industry (e.g. identification of global transactions – operated by GS1 US, therefore, in the USA), food service and catering industry (food quality improvement), healthcare (e.g. patient handling, fixed assets record keeping). Traceability is also a system for automated lot tracking (Fig. 2).



**Fig. 2.** Lot traceability

Source: A. Szymonik, *Informatyka dla potrzeb logistyka(i)*, Difin, Warszawa 2015, p. 129.

<sup>31</sup> OEM *Original Equipment Manufacturer* – a company that sells as its own brand products manufactured by another company. The term is misleading as OEM is not always the manufacturer or even the producer but merely a seller of equipment to the end-user, although sometimes it happens to be its designer.

## 7. Food safety in practice

A cogent dictum that follows from interviews conducted with experts responsible for food manufacturing is this: today's standards for food products for immediate consumption require them to be tasty, nutritional, of highest quality (safe) and freshness. The experts claim that satisfying these requirements is exceptionally challenging due<sup>32</sup>: continual changes in supply, distribution caused by new techniques, technologies, intensive farming (large profits, use of efficient machinery, use of chemicals, fertilizers, insecticides, etc.); operation of – an upward trend – super- and hypermarkets, institutional food service companies, and street food vendors; changes in the natural environment – it is exposed to contamination/pollution (intentional or unintentional) mainly caused by factors related to the global civilization; lengthening supply chains due to procurement of low-cost raw materials from global suppliers and the pursuit of remote markets; competitors' business practice, sometimes unethical.

All this is conducive to an increasing likelihood of proliferation of food of poor quality, sometimes contaminated, and many a time posing a threat to human health or human life, and also negatively impacting on the natural environment.

In order to provide the highest level of food safety the HACCP and IFS systems have been implemented in the studied companies.

They facilitated the development of many instructions and procedures that ensure that the manufactured food is safe and human and environment friendly. The main aim of compliance with the requirements of the aforementioned standards are as follows: committing top management to their responsibility for food safety and quality; raising employees' awareness and competences, sorting out authorities and responsibilities of persons in charge of food production or food services provision.

In the area of logistic processes, according to experts, several issues are of crucial importance and should be considered for the physical flow – starting from raw materials to production and distribution of food – was monitored and managed properly and at once safe. Below are some of them:

**The first.** Procedures for the selection of suppliers should be developed and approved. Purchased materials and services that have an impact of food safety and quality should be monitored and controlled whereas the metrics used for that purpose should have clear evaluation criteria. Supplier performance reviews should be systematically analyzed in the context of threats and types of risk.

**The second.** It should be ensured that raw material and packaging suppliers are subject to regular inspections (this is also directly implied in the IFS and BRC standards); should non-conformities reoccur, inspections without prior notification should also be carried out.

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<sup>32</sup> See A. Szymonik, *Bezpieczeństwo żywnościowe*, [in:] *Logistyka* 2015/5, p. 1543.

**The third.** The primary instrument for the control of logistic systems of suppliers related to food safety are internal and external audits that should concentrate on<sup>33</sup>:

- resources (infrastructure, technical equipment, workers, etc.);
- following procedures and instructions included in the documentation of the quality management system;
- technical documentation (instructions, analyses, control plans, flow-charts, plant layout, etc.);
- validation and activities related to food production;
- control of machines, instruments, measurement and control equipment;
- monitoring of workstations and work environment;
- due diligence as regards workers and their training;
- control of production and production planning;
- monitoring logistic processes in the warehouse;
- control of non-conforming products and corrective actions concerning the non-conformity, etc.;
- compliance of the requirements of the food safety system with customer requirements;
- control of suppliers related to complaints, audits, and supplier evaluation.

**The fourth.** During the performance of warehouse processes, due diligence should be given to checking whether received goods, including packaging and labels, match the specification; checking raw materials, intermediate goods, finished goods storage conditions and preventing cross contamination; checking whether labeling is up to date to facilitate proper management)first in, first out – FIFO or first expired, first out – FEFO).

**The fifth.** Based on the analysis of threats and types of risk and product destination, the company must have a specification for packaging materials. They must be: compliant with the requirements laid down in standards and laws; suitable for specific products (e.g. organoleptic, storage, safe for the product, the human, and the environment); facilitate traceability; they need to have clear, permanent labeling that meets applicable requirements; be subject to regular, documented inspection.

**The sixth.** Extremely important links in the provision of food safety are: properly performed maintenance and repairs which must not have a negative effect on the product; properly designed, prepared, used social facilities; separate changing rooms for the personnel, contractors, visitors; washrooms, toilets that fully ensure hygienic and sanitary conditions (e.g. touchless elements of equipment, proper equipment to maintain sanitary and hygienic conditions, signage explaining requirements concerning hand hygiene, a touchless waste bin).

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<sup>33</sup> See *Quality Assurance Poland*, [www.haccp-polska.pl](http://www.haccp-polska.pl), 10.10.2018.

**The seventh.** Food manufacturers attach great weight to food defense and third-party control. Actions performed during these activities include<sup>34</sup>: designating persons responsible for food defense; regular analysis of threats and types of risk associated with them; development of procedures that are systematically tried and tested in practice (e.g. during trainings or additional exercises); protecting the entire organization against unauthorized access.

**The eighth.** An additional element influencing food safety are doubtless special food certificates issued for particular groups of goods. Taking palm oil as an example as it is an ingredient in a large number of food products available from sales networks, a number of different types of certificates are presented.

One such certificate is RSPO<sup>35</sup> which certifies that the palm oil used for production originates from farming that has caused no harm to the natural environment and ensures fair treatment of people inhabiting the areas where palm trees are grown. The aim of the RSPO activity is to implement and develop standards for sustainable production of palm oil and its global processing on each stage in the supply chain starting from the growers and producers of palm oil and ending with retailers. Subject to certification are plantations as well as companies who use palm oil. Everything is carried out within the RSPO SCCS<sup>36</sup> supply chains that guarantee that the palm oil used in the product came from certified actors (intermediaries).

**The ninth.** As a result of a study, in Germany, it was found that cardboard packaging used for food products contained substances harmful to human health. It turned out that there were various undesirable chemical substances on the surface of the packaging (including benzophenone, bisphenol, phthalates, mineral oils commonly used in paints, UV varnishes, and glue) that migrated inside and contaminated the stored food.

To ascertain harmfulness, results of studies on different types of cardboard cartons and their resistance to MOSH<sup>37</sup>, POSH<sup>38</sup> and MOAH<sup>39</sup> mineral oil migration. It was unequivocally confirmed that undesirable substances (harmful) were present in almost all cardboard cartons because of scrap paper admixture

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<sup>34</sup> Food defense concentrates on protection of food resources against intentional contamination with various chemical, biological or other harmful substances by people who wish to harm the organization or the population. Substances used for deliberate contamination of products may contain compounds that do not naturally occur in food or have not been examined for food contact. The attacker may aim to harm the food manufacturer, the economy of a specific country or to kill people. Intentional acts are rarely rational and are difficult to predict. K. Godlewska, *Forum Mleczarskie Biznes* 2/2014 (18), [at:] <http://www.forummleczarskie.pl/>, 20.07.2018.

<sup>35</sup> RSPO *The Roundtable on Sustainable Palm Oil*.

<sup>36</sup> SCCS – *Supply Chain Certification Standard*.

<sup>37</sup> MOSH – *Mineral Oil Saturated Hydrocarbons*. Once ingested, they accumulated in many body organs and may lead to liver damage, heart valve damage and lymph node damage.

<sup>38</sup> POSH – *Polyolefin Oligomeric Saturated Hydrocarbons*.

<sup>39</sup> MOAH – *Mineral Oil Aromatic Hydrocarbons*, ingestion increases the risk of cancer.

i.e. processed newspaper paper, paint, solvents, gluing agents, etc. On this account, it is recommended that food is additionally packaged in foil bags inside the cartons or that the inside surface of the cartons is lined with foil to provide a barrier to external factors.

In January of 2017, Commission Recommendation (EU) 2017/84 was published which states that Member States should monitor food and materials and articles intended to come into contact with food for the presence of mineral oil hydrocarbons (MOH).

The work on a regulation concerning MOHs in food and in materials and articles intended to come into contact with food is ongoing and therefore the German draft of a statutory law on mineral oils has been adopted as a source of reference.

## 8. Conclusion

Only a number of areas that impact on food safety have been discussed. In the opinion of experts, the best procedures, instructions, advanced techniques will turn out to be of no avail, should the human fail, which may be exemplified by the incident in Germany where a random citizen poisoned food jars with glycol. Investigators established that the amount of glycol injected into the baby food jars could have killed five children. The poison was also found in meals for adults. Only luck and exemplary performance of the police prevented any child from ingesting poison. The contaminated food was planted in the stores in Friedrichshafen. In the emails he sent, the perpetrator threatened to poison products sold in the supermarkets across Europe. To abandon the plan, he asked for 12 million euro<sup>40</sup>.

Issues related to food safety in the supply chain are an important and are bound to evolve. At this moment, food fraud and attempts to counterfeit food products of established brands or eco products are a growing problem. Today, there are still many companies that have yet to go from copying solutions offered by food safety management systems to continual management of a changing market<sup>41</sup>.

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<sup>40</sup> See <https://www.o2.pl/>, 22.10.2018.

<sup>41</sup> See *Producenci zaczynają dostrzegać ryzyko związane ze zjawiskiem fałszowania żywności*, [www.portalspozywczy.pl](http://www.portalspozywczy.pl), 27.10.2018.

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# VISIONS AND DIRECTIONS FOR THE DEVELOPMENT OF LOGISTICS 4.0 IN CONTEXT 4.0 INDUSTRIAL REVOLUTION (LEVEL 4.0 – L.4.0)

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**Abstract:** the author presents in the paper the general assumptions of logistics 4.0 in the level of the 4.0 industrial revolution. The publication was based on a literature study and already implemented logistics solutions in enterprises, corresponding to level 4.0. The article is an attempt to present vision and directions of logistics development in mature cyber-physical systems of production and customer service. The publication is also a voice in the discussion on the possibilities of developing logistics in the search for answers to the question: Logistics 4.0 myth or reality in the modern Polish economy.

**Keywords:** industrial revolution, industry 4.0, logistics 4.0.

## 1. Introduction

With the development of industry, changes are introduced in logistics systems and solutions. The level of the industrial revolution, referred to abbreviated as level 4.0 – industry 4.0, is, to a large extent, the IT and physical integration in the area of production and beyond. The IT integration includes, among others, data collection and analysis (Big Data, Cloud Computing), mobile communication (M2M – Mobile To Mobile), control of IoT–devices and functions via the Internet (Internet of Things and IoS – Internet of Services, linking the logistics system with e-commerce systems. Physical integration is primarily cyber-physical production systems (CPPS as Cyber-Physical Production Systems) without the participation of directly production workers (manual workers), automatic loading and unloading, fast stock replenishment in the warehouse, picking individual customer orders, quick paths for picking processes [1].

Cyberphysical solutions are used both in individual manufacturing enterprises and in the entire value chain. In logistic terms, new solutions constitute a system for collecting and processing data in the area of the entire value chain, including the means of production, storage systems and networks of sub-suppliers [2]. Information in the supply chain is exchanged between CPPS elements through standardized communication interfaces and is available globally for human use in operational or maintenance activities [3]. Enterprises equipped with cyber-physical production lines and modern systems of production control and

communication at a distance are referred to as Smart Enterprises or Smart Factories (agile, flexible, virtual). Such entities are a hybrid of solutions belonging to the physical world and the virtual world. There is integration of IT (IT/office) and OT (operational/production) systems. IT systems are used, among others, for logistics planning, customer relationship management and decision support in the company. Operational systems are used to monitor the operating conditions of devices and control them, as well as to control processes. Within industry 4.0, it is necessary to combine these two worlds: real / physical and virtual/IT [4,5].

In new forms of business relations with the valorisation of digital resources, large amounts of public data, entities operating within the framework of the Internet of Things and Services and distance communication systems (M2M), new logistic systems are created inside enterprises and throughout the supply chain.

The main objective of this publication was to present the logistics concept 4.0 in a narrow perspective – internal logistics of the company and, broadly, in the value added chain. A complementary (additional) objective was to discuss the feasibility of new solutions referred to as logistics 4.0 in the conditions of the native (Polish) economy.

## **2. Visions and directions of logistics development – logistics 4.0**

In the literature on the subject [6-10], individual phases of logistics development have been described in detail, beginning with the start phase (logistic awakening) in the USA in the mid-1950s, through the phase of continuous development, in which components of the subphases distinguish themselves with visible changes in logistics, e.g. the end of the 1980s, creating integrated strategic management of all logistics activities in the procurement, production and distribution phase (logistics integration implemented in these years was in highly developed countries), up to the development of national and global flow processes in the 1990s (development micrologistics, monologistics, macrologistics, eurologistics and global logistics). In the early 90s of the last century, the system of effective customer service (ECR – Efficient Consumer Response) was established in the USA, and the automation of flow and storage at the end of the 90s and the beginning of the 21st century. The end of the 1990s and subsequent years are considered to be the phase of dynamic development of logistics due to the scope of changes. Modern logistics uses the latest IT and automation solutions in process control. It is assumed that industry 4.0 solutions (initiated by the government in Germany – 2011– Industry 4.0 is an integral part of High-Tech Strategy 2020) gave rise to logistics 4.0 [14-15].

Logistics 4.0 is a term referring to modern logistics in the supply chain, including mutual data exchange, digitization and cloud computing. Intelligent and digitally connected systems create communication between people, machines, equipment, logistics solutions and products [16]. In logistics 4.0, two aspects are taken into account:

- process (value chain as a logistic object)
- technical (tools and technologies that are used in integrated processes within the supply chain).

There are similarities between logistics and industry 4.0 in the field of applied solutions, which include:

- digitization (digitalization),
- automation and robotization,
- cooperation networks,
- mobility – remote communication [17-18].

Technological solutions used in Logistics 4.0 include, among others: drones, autonomous vehicles, sensors, Big Data, GPS, RFID, M2M.

Logistics 4.0 is captured in a narrow perspective as a form combining relations and processes between independent participants using broad logistic solutions using databases [19]. In a broader sense, logistics 4.0 is related to logistics systems equipped with the latest IT and computer solutions and using innovative tools and logistic technologies available (considered to be competitive) at the level of Industry 4.0 [20]. Logistics 4.0 consists of logistic systems [21], which are constructed of independent (separate) subsystems. The behavior of individual subsystems depends on the factors of the environment and the circumstances of individual participants. The term Logistics 4.0 also means the process of automation and co-organization in deliveries implemented in Industry 4.0 [22]. Information exchange in supply chains uses the Internet of Things (IoT), which facilitates searching, data updates, and material and resource identification in the supply chain [23-25].

In the new solutions, the structure of the value chain changes in the approach of M. Porter (evolution of M. Porter's value chain). The concept of M. Porter's value chain [26] the product or service moves one-dimensional to subsequent organizational units (each adds value). In the new industrial reality (Industry 4.0), value networks are constructed that are multidimensional. The source of values is the combination of network links (Net of Value Chain), based on interoperability. The functioning of the value network is based on: Internet business platforms [27]. The Internet allows service providers to offer their services, and individual offers are available and available on request and are characterized by the possibility of mutual integration. In the online reality it is possible to sell more (long tail) and develop individual and niche products whose share in the sale of a given assortment becomes dominant with a developed information exchange infrastructure (production of products that once was unprofitable or even unconscious becomes real in Industry 4.0) [15].

In the structure of M. Porter's value chain, individual activities in logistics 4.0 have changed. The first basic activity is input logistics (raw materials, semi-finished products must physically exceed the gate of the plant and must be subjected to quantitative and qualitative verification). Here, in logistics 4.0,

autonomous vehicles (unmanned vehicles), conveyors, sensors, readers, codes, chips, sensors, etc. are used. Wireless data transfer technologies with tags operating in the RFID (Radio Frequency Identification) system enable the control of the position of the goods in the warehouse and control position in transport. The dissemination of this technology is also connected with the anticipated development of the Internet of Things [28]. There are systems on the Polish market that control logistic processes, such as IPOsystem (one of the functions of this system is to calculate the current deadlines for all orders up to minute). Systems optimize the functioning of the entire organization - independently managing devices and employees in production, internal transport, stock, procurement and quality control [29] In logistics 4.0, there are so-called products memory, that is, products that have individual, prior to manufacturing, all necessary information regarding production requirements. The product communicates with cyber-physical production systems during the entire course of implementation, using mobile technology.

The resources go directly to production, so the warehouse may be unnecessary. A similar solution has already occurred in the Japanese production systems (TPS – Toyota Production System) [30]. During production operations a new product is created but it is a highly personalized product [31]. Apart from IT and computer systems (CAD), product customization also enables technical solutions, e.g. 3D printers and intelligent chatbots (robots that act as trade assistants, virtual consultants, automated resellers, advisers, assistants or complaints handling). Do customers want to be served by artificial intelligence? [32]. An example of how to adapt the product to the client's physical characteristics is, among others, the About You platform. In level 4.0 of changes, production devices do not create an article according to a defined procedure, the product itself communicates to the machines subsequent processing stages [33].

The output logistics process organizes the dispatch of goods according to orders. So far, all these activities have been monitored by the Marketing and Sales Department, which in practice is also called the Sales Department. At level 4.0, customer service is unmanned as part of the mobile services service. In the value chain of M. Porter, the Sales Department was an extremely important cell in the company. Because the ability to acquire and retain customers translates into orders placed. In logistics 4.0, the customer is looking for the best solutions for himself, and individual personalized products will be counted in hundreds of millions creating mass individualisation [34-35]. Intelligent logistics (Smart Logistics) uses intelligent products (Smart Products) and intelligent services (Smart Service) [15.3]. Examples of intelligent products are: machines that recognize service needs and generate messages, if service is required, containers for goods informing about necessity content replenishment. Intelligent products and intelligent services offer the ability to measure, supplement what can not be measured earlier or supplemented on a regular basis.

Logistics at level 4.0 consists in accepting from the manufacturer all distribution processes, as well as price negotiations or product insurance. In

logistics 4.0 there is a horizontal integration along the value network (horizontal integration through value networks). At level 4.0, horizontal integration is based on digitization, which results in the flow of information in the value network – from the customer through the manufacturer to the supplier, and vice versa. Horizontal integration includes both components of the value network within the company as well as the network of subcontractors. The exchange of information concerns not only the flow of goods, but also data defining the reliability of deliveries and customer satisfaction [33].

### **3. Voice in the discussion: Logistics 4.0: myth or reality in native (Polish) conditions?**

The current conditions for the operation of logistics companies in Poland are largely the result of processes that have taken place in recent years. It should be clearly stressed that in comparison with highly developed countries, domestic enterprises do not have much business experience (low experience effect). In Poland, the market economy has been in operation since 1989, and domestic capital must compete with strong foreign capital. According to the experimental curve [37-39], the accumulation of experiments allows companies to reduce manufacturing costs. Difficulties in the practical application of innovative solutions in logistics 4.0 are, above all, high costs of new solutions. Logistics 4.0 requires actions in the form of modernization of accessories and procedural changes.

Logistics in Poland in recent years has been conditioned by infrastructure investments. In the national strategy for regional development 2010-2020 (Regions, cities, rural areas, M.P. 2010 No. 36, item 423, Resolution No. 60 of the Council of Ministers of 30 April 2014 on the adoption of the "Strategy for the Development of Western Poland until 2020. M.P. 2014 item 452, Resolution No. 3 of the Council of Ministers of January 8, 2014 regarding the adoption of the "Strategy for the Development of Southern Poland until 2020." M.P. 2014 item 152. – Poland 3.0) The strategic goal is to develop various forms of transport and their integration (the focus is primarily on transport: air, inland water, in the second car, in the third on rut, pipeline is, among others, investment in Świnoujście – a port for processing of gas imported from foreign countries from countries of Eastern Europe). In the perspective of 2020, it is difficult to talk about the logistics development perspective 4.0 (very short time horizon). The future of logistics 4.0, mainly in the context of achieving the assumed goals or constructing development plans, should go beyond 2020. This applies, inter alia, to the expansion of infrastructure, the emergence and continuous improvement of which allows a faster, less expensive, more environmentally-friendly form of transport [1].

Another example related partly to the infrastructure is the development of the IT network – digitization of the country. Information is currently one of the basic resources that guarantees the functioning and development of a modern enterprise. Innovations have been and are a driving force for the development of particular fields of activity [40-41]. However, it is worth remembering that the latest solutions known as cyber-physical systems of production and customer service at a distance are very expensive. They may also not take into account the specifics of a given company. It is a common practice to write individual IT programs and construct individual solutions in the field of automation and robotization of works at the request of production companies and logistic companies. In addition, to ensure installation flexibility, IT systems must work on the same networks based on the same servers as the operating systems. This, on the other hand, sets new requirements for network components used for data transmission. New standards are being created, but they are being introduced gradually, and must be introduced in order to bring together these two groups of IT and OT solutions. There are already solutions on the market that enable the synchronization of devices connected to one classic Ethernet network, without the need to use its industrial equivalents, through the use of Ethernet routers, supporting the new standard, it is possible to transmit data in industrial networks (OT) that connect to office networks (IT), e.g. Time Sensitive Networking technology, developed within IEEE by companies such as Cisco and Intel. The use of the potential of combining data from various sources is the key to the success of a modern company and increasing its competitiveness in a dynamically changing business environment. Expansion of the data exchange network. In practice, it means an increasing number of objects and products with the ability to generate, transmit and process information. Current and upcoming trends, security, protection of sensitive data and the prospect of developing such concepts as the "Internet of Things" require new technological and logistic solutions (security systems) [1].

Logistics 4.0 seeks to reduce the demand for employees. It is assumed that the benefits of implementing new, fully automated logistics solutions are eliminating many errors that originate from a human being and which have specific consequences for efficient product delivery to the market. There are systems on the market, e.g. IPO system, which independently controls machines, transport devices, robots, 3D printers, but also issues instructions to employees serving the production process, as well as supervising human work. But do employees want to be supervised and directed by systems? Man wants to have control over devices, and not only be controlled by devices. Will the high independence of devices support the professional development of employees? Authors of publications [42-43] indicate that there will be a change in the professional structure of employees, the demand for IT specialists, analysts, planners and constructors will increase. Does the domestic market have a sufficient number of employees with the required qualifications?

It also seems reasonable at the level of management to emphasize the importance of the Maintenance Department, which will be replaced with learning

devices. Individual devices are self-learning devices (learning machines) that process current data from the data cloud and learn to perform their tasks optimally, while simultaneously calibrating the adjustable operational parameters [44]. By limiting the number of device operators, there may be a problem of the lack of control over the independent devices in the situation of threats.

In logistics 4.0, the emphasis is on time management (time compression) [45]. Delivery of goods within 24 hours from placing an order by the customer is a development of the Just-in-Time delivery system was strongly exposed already in the 90s of the last century, Polish companies that wanted to compete on international markets had to deliver their products within 24 hours. At that time, however, the ordered goods were homogeneous or offered in the standard offer of the company [30]. It is currently to be personalized. With a high level of competition on the market, the struggle to deliver product innovation to the market may be difficult for domestic capital (especially medium-sized and small enterprises). It is expected that along with the increase in the speed of data flow and the growing availability of commercial offers on the Internet, the emphasis on the rate of delivery will also increase. Individual distributors, such as Amazon, test solutions based on deliveries within one hour of placing an order. However, this applies only to some regions with high population density like Manhattan in New York [46].

Taking into account, for example, demographic trends (aging of the population, generation gap in enterprises) [47] in the future, logistics will have to meet the new requirements of work ergonomics. The anticipated growing share of older people and women working in logistics will create additional requirements for the ergonomics of workplaces and employee support with additional equipment facilitating work [48-50].

Another issue is environmental protection: the growing importance of ecological concepts and solutions clearly indicates the need to implement energy-saving solutions and the wide use of renewable energy sources, new materials, e.g. self-cleaning clothes, ceramics that emphasizes energy, graphene, light construction, recycling of natural resources (even in small quantities from individual devices, e.g. platinum from car catalysts), 3D printing [4], etc. Meanwhile, the domestic market can be seen to increase the price of energy with high energy intensity of individual industries. Domestic enterprises must use the opportunity to access energy-saving technologies to gain a competitive advantage.

In the social aspect there will be a change in the model of life, Society will have to learn to balance the forms of spending time with family and loved ones without the use of technology and sometimes devoted to the HT). – use of the latest technology (Hight Tech Propagated is a tech-life harmony model in which mobile devices: telephones, laptops, autonomous vehicles (e.g. cars, drones), robots, working in factories and at home (cleaning, cooking) did not take possession of man.

## 4. Summary

Logistics 4.0 and actually there are components (components) in various forms of process organization and levels of technical innovation advancement are already present in some enterprises of industry sectors, e.g. steel constructions (Thyssen Energo Stal- warehouse in Dąbrowa Górnicza), food industry, clothing (sales portal: About You), automotive and household appliances (Bosch). Innovation solutions implemented are to serve [1]:

- greater focus of logistics activities on customer expectations, creating new values and usability for the client (personalized products);
- focusing on key competences, outsourcing more and more functions and logistic activities (taking over distribution activities from producers by specialized companies);
- shortening the product life cycle in connection with the pressure to shorten the product creation cycle and the time of reaching the final recipient (even up to 1 hour);
- introducing innovative IT systems allowing for full integration of activities within the supply chain, increasing the flexibility of operations;
- increasing the importance of modern forms of transport and reloading (unmanned vehicles);
- increase in the number of shipments in combination with the concepts of e-commerce and a mobile society (using the most-expensive IT solutions).

Innovative solutions in the areas of IT and OT, however, require significant financial expenditures and are the subject of corporate strategy in the perspective of a dozen or so years (except 2020, the extended perspective of changes in the logistics area 4.0 applies especially to domestic companies that are looking for sources of cost dominance in conditions of strong competition with websites of foreign enterprises).

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# THE PRESENCE OF A MAGNETIC SEPARATOR AND THE EFFICIENCY OF THE PROCESS

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**Abstract:** The aim of this study is to indicate the connection between the lack of implementation of magnetic separators and a variety of losses occurring in the processes of the surveyed companies, and thus increase the risk of food insecurity produced by the surveyed companies. Brainstorming with Magnetic Poland experts, analysis of documentation allowed to identify the most important determinants, resulting from the lack of magnetic separator in the company, influencing the losses in the production and logistic processes of the surveyed companies. During the research process, a group of Magnetic Poland's customers were asked to indicate the key problems they faced before the introduction of separators in their production processes. The implementation of separators allowed to reduce losses in production processes related to machine failure, eliminate the risk of receiving poor product quality and interruption of the continuity of supplies. Identification of key factors allowed us to present their impact on the efficiency level in the processes.

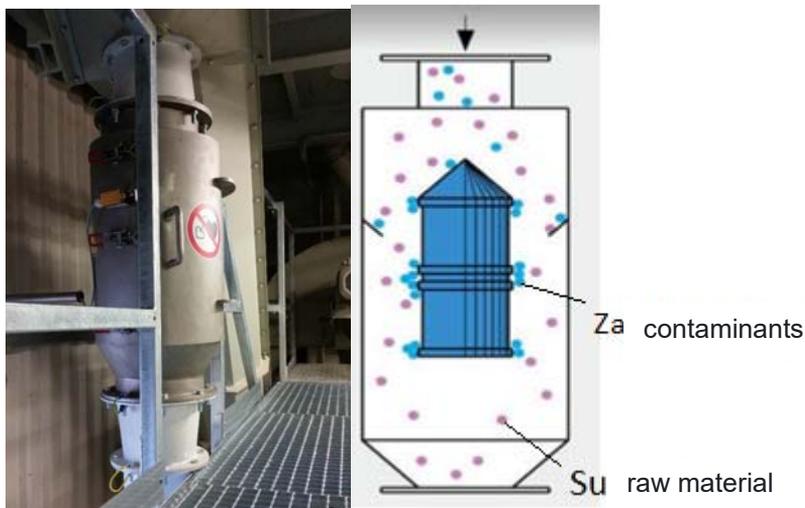
**Keywords:** effectiveness, risk of losses in processes, wastes, food safety, magnetic separator presence.

## 1. Introduction

Conical separators are installed in existing pipelines, which transport loose raw material (usually grain), in the middle of the casing in the shape of a cylinder there is the so-called separator core. It consists of a cylindrical part and a conical part, from which the commercial name of this type of device comes. This device works on the principle of gravitational flow of separated material through the separator [1]. The device is constructed in such a way as to maximize the possibility of contact of the cleaned medium with the magnetic core, through "scrapers", which direct the medium centrally into magnetic rings. As a result of the magnetic field produced by the permanent magnet, all ferromagnetic impurities (Fig. 1) are attracted to the core and the cleaned raw material flows to the further part of the process.

The absence of a magnetic separator or its damage in installations of equipment in food production processes is a factor of instability of the production process [2] and causes a variety of losses, is a factor increasing the occurrence of

various risks. One of the key factors is poor product quality and consequently lack of food safety, which translates into bad customer relations and loss of good company image in the supply chain. In addition, there are a number of problems such as production stoppages associated with machine stoppages, machine cleaning and failure rates, all of which result in companies' failure to achieve their productivity targets, and also the interruption of continuity of supply to their customers.



**Fig. 1.** Conical separator installed and its principle of operation

*Source: own elaboration.*

This fact prompts food companies to identify key control points in production and logistics processes where the presence of magnetic separators is desirable. This translates into increased efficiency of production processes, reduced risk of poor quality deliveries, compliance with the requirements of the HACCP system and the compliance with the required delivery dates.

## 2. Methods used in the research process

Four steps have been established, in order to indicate the relationship between the absence of a magnetic separator or its malfunction and emerging losses in production processes and the lack of food safety.

1. Identification of losses resulting from the lack of a magnetic separator on the basis of the analysis of problems existing in customers of Magnetic Polska – case studies on the basis of records of complaints and requests for proposals.

2. Analysis and assessment of the risks associated with the absence of a magnetic separator in the context of existing losses in production and logistics processes, and on this basis, identification of factors determining losses and process risks.
3. Determination of the significance of particular factors and indication of key process losses and ways to eliminate them.
4. Presentation of new innovative technological solutions.

In relation to the adopted research process, a number of tools and techniques were used, such as direct interview, analysis of data and records of Magnetic Polska and the surveyed enterprises, brainstorming tools, such as a thought map, Ishikawa and 5xWhy chart and a correlation table.

### ***2.1. Analysis of documentation in Magnetic Polska company***

The analysis of the documentation was divided on two groups. The first group included complaints sent by customers of the manufacturer of magnetic separators concerning damage to the device during operation or insufficient performance of the established tasks. The second group consisted of enquiries from potential customers addressed to the producer of magnetic separators. The main attention was focused on the reasons for these questions. Complaint documents were received mainly by e-mail, where the type of defect was described in the e-mail, sometimes accompanied by photographic material.

The most common reason for complaints by purchasers of separators was their mechanical damage preventing further work. This situation concerned mainly the feed and food industry, where pipe separators (conical) are most often used – Fig. 2. These separators are installed mainly at the beginning of technological lines in order to carry out preliminary purification of the received raw material.



**Fig. 2.** Example of mechanical damage to the magnetic conical separator

*Source: own elaboration.*

The most popular reason for the complaint was mechanical damage to the conical part of the separator or to the "pipe casing". These damages obstructed further operation of the separators, which resulted in the lack of protection of the production line at this stage and the appearance of the risk associated with the appearance of metal parts in the product.

The second most popular reason for advertising separators was "clogging" of equipment. The problem was that the efficiency of the technological line was too high in relation to the capacity of a magnetic separator of a given diameter. This problem did not occur as often as mechanical damage, but unlike it, production had to be stopped during the occurrence of clogging. This definitely disturbed the continuity of operations, because in order to unblock the device, it has to be cleaned and emptied of excess material, which requires stopping the production line for at least 30 minutes.

The reasons for queries from potential customers were also the basis for the analysis of the manufacturer's documentation. Incoming customers' inquiries from the period of two years were examined. The common element of all inquiries was ferromagnetic contamination entering the production process. The incoming inquiries were divided into two groups:

- contamination causing machine failure, downtime, unplanned repairs and maintenance,
- impurities causing deterioration in the quality of the product, failure to meet the quality requirements.

For the first group the main problems were impurities of large size, such as: M8 screw, nut, nails, pieces of wire, which entered the process together with the raw material (in this case mainly grain). These contaminants are very dangerous for the company's machinery, especially for all kinds of mills and shredders. Damage of this type generates long downtime and high cost repairs. Analyzing the impact of such defects on customer relations, the following elements are by far the most important:

- downtime as a result of breakdowns, which may affect delivery delays, discontinuity of deliveries or non-performance of orders;
- repairs generating high costs, coverage of which may result in a price increase.

The analysis of the documentation made it possible to identify key aspects related to downtime issues, failure of machinery and equipment and lack of assurance of safety of manufactured products.

## ***2.2. Analyses with the use of tools Problem Solving***

Within the framework of the conducted analyses, the following Problem Solving tools were used: Ishikawa graph, 5xWhy and mind map.

For the purposes of the research, a thought map was created referring to the impact of the absence or malfunction of the magnetic separator on the production process, taking into account the relations with customers. The principal directions of development of the mapped thoughts and associations were:

- product quality,
- quality of processes,
- lack of continuity of deliveries to the customer,
- losses in processes.

When creating mind maps, the costs that the organization will have when the magnetic separator will be damaged or will not be installed in the process line and the risks that will arise due to this fact were mainly taken into account. In particular, attention has been given to the consequences that have a negative impact on customer relationships.

On the basis of the Problem Solving analysis, it was found that the most important hazards related to the lack of a magnetic separator or its damage in the process are:

- break in continuity of a supply chain,
- lowering the quality of the product,
- process losses: waste, time losses,
- breakdowns, damage to machinery.

The most common notion appearing in the mind map is the losses that are widely understood:

- time – resulting from stoppages, waiting,
- costs of utilization and improvement of the quality of defective products,
- costs of customer returns and complaints,
- losses due to damage to machinery,
- no profit.

The selection of the above-mentioned research tools helped to identify the key factors influencing the lack of process efficiency resulting from the absence or damage to the magnetic separator. These are:

- lack of appropriate standardisation,
- the technical condition of the machinery,
- the competence of employees,
- maintenance department management,
- quality of the raw material,
- working environment.

Problem Solving tools allowed the entrepreneurs to thoroughly study the problem and indicate the most important causes of reported problems.

### **2.3. Research tool**

On the basis of the information obtained during both research stages and the mind map, a questionnaire was prepared.

Verification of the relevance of the identified factors and obtaining information on the assessment of the relevance of potential effects and events caused by the lack of a magnetic separator in the material flow process was the main goal of research based on questionnaire surveys.

The tool consisted of three parts, each of which concerned the assessment of:

- the causes of irregularities in the processes,
- hazards arising from the absence of a separator,
- the impact of irregularities and losses on the processes performed.

The survey was conducted electronically by via docs.google.com/forms.

In the first part, the respondent answered questions about the company he represents and whether magnetic separators are used in the production plant where he works.

Next, the examined person answered questions related to possible causes of irregularities in the process of material flow caused by the lack of magnetic separators. The evaluation of factors took place in the five-stage Likert scale, from 1 (which meant little significance of the factor) to 5 (which meant very high significance of the factor).

In the next part, the potential risks resulting from the lack of a separator in the production process were assessed. Mainly all types of losses resulting from irregularities caused by the penetration of iron contaminants into the raw materials in the production process have been taken into account. Some of the respondents assessed the risks based on their own experience with separators, while the other respondents identified these risks as potentially occurring in their manufacturing processes.

In the third part of the questionnaire concerning the whole research group, the potential effects of the aforementioned threats in the context of the quality of the production process were asked.

The study also asked about the effectiveness of magnetic separators in the companies where they are installed.

### **2.4. Test sample**

The research sample selection was based on the guidelines contained in the book by M. Szreder [4, pp. 50-51] and non-probabilistic and non-random techniques were used, which are based on the subjective selection of elements made by the researcher, based on his own assessment, experience or knowledge. The researcher himself indicates the elements of the population which will form the research sample. These elements meet predefined characteristics or are representative from the point of view of the studied population.

Bearing in mind the presented literature data, a group of 35 customers of the magnetic separator manufacturer were selected for the research, who within the period of 2 years submitted a demand for a magnetic separator or such a separator were bought.

The most significant criterion for selection to the research sample was the knowledge of the subject of magnetic separation and separators by the examined persons. This was very important because they were also used as experts on the effectiveness of the discussed devices and their impact on the process and customer relations.

### **3. The results of the research**

According to the assumed criterion of knowledge of the separation process and magnetic separators, 35 companies were selected for the research. The questionnaire was completed by 30 of them. The research was conducted in the period from September to December 2017.

#### ***3.1. Causes of irregularities in processes***

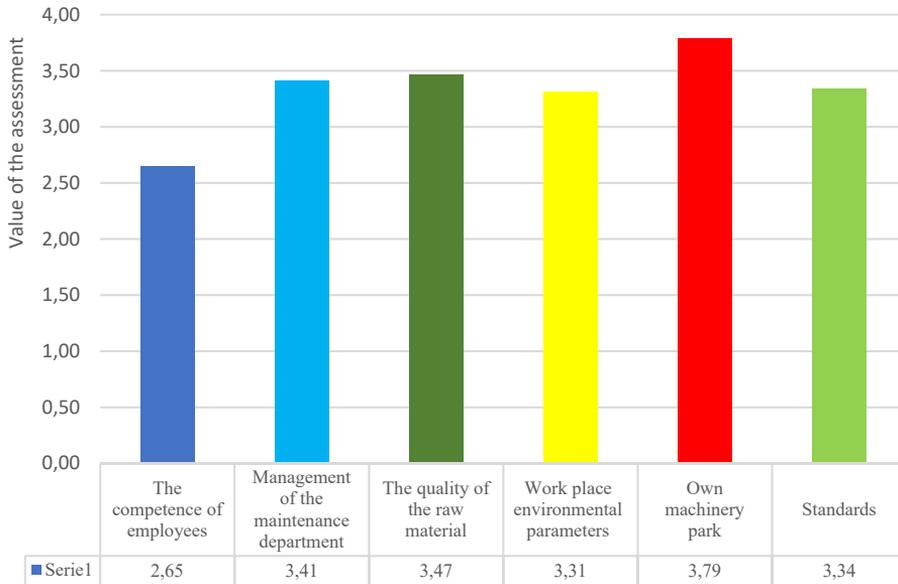
The analysis based on data from the complaint process obtained from the manufacturer of magnetic separators and Problem Solving tools made it possible to identify six important causes of manufacturing losses in the context of ensuring food safety – Fig. 3. As part of the questionnaire survey, respondents were asked to evaluate individual items according to the Likert evaluation scale assumed in the questionnaire. The results of the survey indicate that the most important of the identified factors are the machine park, material quality and maintenance department management. Other elements are the factors that are the effect of the management process in enterprises.

The discussions with customers clearly indicated that the machine park equipped with a magnetic separator is a fundamental element of ensuring proper process efficiency and allows for the production of safe food and reduces the risk of shortage of supply in the supply chain.

Another determinant is the quality of the material, which should be understood as a raw material free from contamination.

The third important issue is process management, as indicated by other determinants – maintenance department management, standardization, environmental parameters and employee competence.

Due to the fact that the condition of the machine park and its equipment are so important, the participants were asked about the elements that may have an influence on the occurrence of various types of losses related to the lack of a separator in the processes.



**Fig. 3.** These are the key determinants of irregularities in customers' production processes affecting process quality assurance and food safety

*Source: own elaboration.*

### 3.2. Losses and risks resulting from the lack of a separator in machine park equipment

In this part of the study respondents were evaluated 15 losses and risks that may occur in material flow processes, when there are no magnetic separators in their structure. The data from the analysis are presented in Table 1.

**Table 1.** Research – hazards arising from the absence of the magnetic separator

	The assessed aspect	Average assessment value
1	Machine failure caused by contaminated raw material	5
2	Decreasing number of customers	4,57
3	Costs of repairing machinery due to contaminated raw material	4,43
4	Poor advertising on the market due to deteriorating product quality and returns and complaints	4,37
5	Loss of customer confidence resulting from a defective product	4,2
6	Loss of time due to breakdowns and machine downtime due to changeovers	4,17
7	Loss of continuity of deliveries of manufactured products in the supply chain	4,17

	The assessed aspect	Average assessment value
8	Returns and complaints of the defective products	4,13
9	Health and life-threatening risks for the end customer resulting from the use of the defective product	4,1
10	Losses due to defective product and its recycling	4,03
11	No profit related to losses resulting from errors in processes	3,8
12	Non-compliance with own orders resulting from downtime, unplanned repairs and failures	3,73
13	Loss of time due to lack of continuity of operation caused by the lack of a separator at the input to assess the quality of raw materials for production	3,27
14	Lost production capacity resulting from the lack of continuity of work due to the lack of a magnetic separator in technological lines	3,2
15	Loss of human potential due to breakdowns and other stoppages	3,13

*Source: own elaboration.*

The assessment made by the respondents indicates that in the case of identified losses at the stage of document analysis and application of Problem Solving approach, the key problem is machine failures caused by contaminated raw material. This factor was assessed by all respondents at the highest level of the Likert scale.

In the next group there are three factors that are the result of failures and downtime that occur as a result of the absence or damage to the magnetic separator in the process line, these are:

- risk of losing customers, especially strategic customers,
- costs of repairing the machine park,
- bad opinion in the market.

In the last group there were the remaining evaluated elements, among which they were rated the highest:

- loss of customer confidence resulting from a defective product,
- loss of time due to breakdowns and machine downtime due to changeovers,
- loss of continuity of deliveries of manufactured products in the supply chain,
- returns and complaints of the defective products,
- health and life-threatening risks for the end customer resulting from the use of the defective product,
- losses due to defective product and its recycling.

The presented results allow us to conclude that the types of losses and risks that occur in business processes due to the lack of a separator may be several dozen times higher than the cost of purchasing a separator for the process.

### 3.3. The impact of irregularities in the process

In the last part of the study, a group of effects that may occur due to the lack of a separator was evaluated. The results of the assessment are presented in Table 2.

**Table 2.** Research – the impact of irregularities in the process

	The assessed aspect	Average assessment value
1	Safety of the final customer of the product (product not meeting the conditions of use/consumption)	4,7
2	Safety of employees during the production process – Iron cause spark/fire/ explosion	4,37
3	Increase in costs related to the utilization of defective products	4,07
4	Loss of time for the customer resulting from failure or waiting	3,87
5	Loss of employees' time resulting from failures and waiting time	3,8
6	Costs of non-compliance with quality requirements	3,57
7	Unnecessary transport/repetition of operations	3,13
8	Repetition of operations	3,13

*Source: own elaboration.*

Among the effects listed above, it was rated the highest the safety of the final customer of the product (product not meeting the conditions of use/consumption) 4,7. This parameter is very important because it shapes customer relationships throughout the supply chain.

The second most important effect is safety of employees during the production process – Iron cause spark/fire/explosion. It is one of the essential elements of management and producer responsibility for its employees.

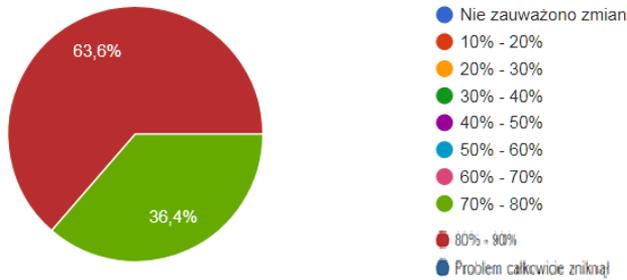
Increase in costs related to the utilization of defective products is an effect that always occurs when there is a problem of poor quality and is closely related to the losses associated with inventory and overprocessing. It is very important because the occurrence of these losses creates a risk of bad customer relations in the supply chain.

Other effects listed in Table 2 are classic losses, which are defined by managers in production processes and are associated with time and cost loss and

create the risk of discontinuity of operations and may translate into deterioration of relations with customers.

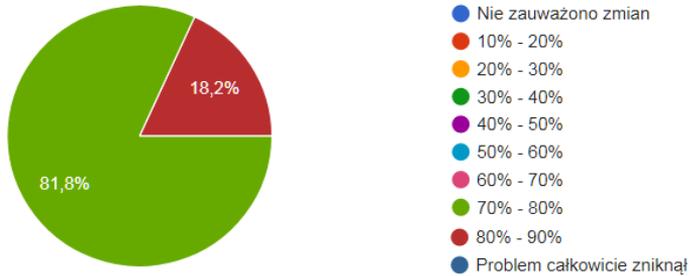
**3.4. Evaluation of the implementation of magnetic separators for efficiency in the processes of the customers under investigation**

The surveyed companies clearly indicate that the implementation of magnetic separators in material flow processes significantly increases their efficiency. This is indicated by the data presented in Fig. 4-6.



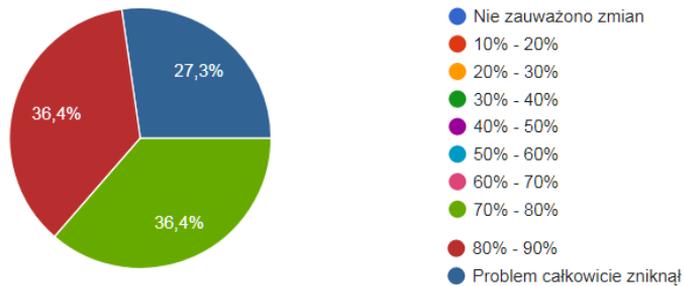
**Fig. 4.** Reduction in the presence of defective products

Source: own elaboration



**Fig. 5.** Reduction in the presence of returns and complaints

Source: own elaboration



**Fig. 6.** Reduction of machine failures due to contamination of raw materials

Source: own elaboration.

Respondents agreed that the use of magnetic separators helped them to reduce or even eliminate the problem of machine failure caused by contaminants entering the process. Elimination of this problem translates directly into lower returns and complaints from the customer. The research confirmed such an impact, because according to the majority of respondents, the number of returns and complaints after installation of the magnetic separator decreased by 70-80%.

Respondents also unanimously confirmed that the use of magnetic separators helped them to reduce or even eliminate the problem of machine failure resulting from metal contaminants entering the process lines during the manufacturing process.

#### 4. Conclusions

The research tools used have clearly defined the losses and risks that occur in material flow processes without the presence of a magnetic separator.

The conducted research allows us to state that the implementation of separators in raw material flow processes eliminates most of the losses defined in the first stage of the research and increases the efficiency of the processes.

The most important benefits of their implementation are:

- raw material and semi-finished products free from contamination,
- machine park safety,
- customer safety,
- safe end product, free of iron impurities.

Due to the variety of raw materials processed, the selection of the separator should be carried out by persons with appropriate experience, as it should include appropriate functionalities that will reduce time wasted on cleaning the separator. The implementation of I4.0 [3] tools should help to identify problems on production lines as quickly as possible and to measure and monitor downtime parameters.

The next stage of the research is the development of a model of relations between the identified elements.

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# CONSUMERS' PERCEPTION OF ECO-INNOVATION IN FOOD SUPPLY CHAIN LOGISTICS AS A FACTOR SHAPING FOOD PRODUCT QUALITY

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**Abstract:** In the second decade of the 21st century, innovations are considered economy's driving force. In the food economy, innovations are distinguished by a number of socially desirable characteristics that allow them to be classified as eco-innovations. The specificity of innovation in the food economy consists in finding solutions whose most important characteristic is not their new character, but a positive final effect that ensures safety and high biological quality of food. The goal of the paperwork was to examine consumers' perception of logistic food supply chains as a factor affecting food quality and to examine the perception of eco-innovation in these chains. The conducted research showed that consumers perceived innovative food primarily through the prism of a product's new character and production technology. Some of the respondents saw the source of innovation in product safety, high content of vitamins and minerals and in organic production, free of GMOs, and some identified it with more schematics. The respondents saw the benefits of short supply chains, but did not use them themselves. The research has shown that consumers' awareness of a close relationship between food intake and their health has been confirmed, as well as consumers' willingness to bear additional costs of high-quality food. The conducted analysis of clusters allowed structuring the beliefs regarding desirable characteristics of food, places of purchase and willingness to buy directly from farmers. The perception of food innovation requires educational activities. To have a positive impact on social health, an educational message, which is not subjected to the pressure of maximizing economic profits but to shape consumers' pro-health attitudes, is important. Considering the fact that health care belongs to the state's tasks, a reliable message about the impact of food on health can be considered an element of health prevention.

**Key words:** food economy, eco-innovation, logistics, high-quality food.

## 1. Introduction

Consumed food is one of the main factors determining human health [10]. Therefore, the quality of food is important not only in the context of health and happiness of an individual citizen, but as a foundation of health it becomes social in nature. High biological and health quality of food can be quantified and valued

in the context of both the costs of treatment and care, as well as lost opportunities as a result of reducing patients' efficiency. Therefore, food that ensures good health is socially desirable, considered as eco-innovation and as such it should be easily recognizable and promoted. Hence, food economy is an important part of Poland's national economy. The domestic food industry is currently considered one of the most modern in the European Union. These changes have been made thanks to large investments in making this branch of the economy more modern. Agriculture and food economy (including the food industry) participate in the globalization process. The consequence is different changes, both positive and negative [3]. Polish people are additionally exposed to double quality standards applied by some Western manufacturers [8], which makes consumers encounter another difficulty in accessing high-quality food.

Logistics and the complexity of the food supply chain is one of the determinants of high-quality food. The length of this chain, as well as technology, condition of processing and products' origin are of great importance in meeting consumers' food needs. When consumers reach for food, they put their trust in the system of its production, and reliable descriptions on labels are to provide information they expect. On the other hand, in their diversity consumers are guided by the choice of products with a complex motivation system, shaped by many exo and endogenous factors. Understanding consumers' perception of food products can improve food quality.

The aim of the conducted research was to obtain answers to the following questions:

1. Do consumers see the relationship between health condition and nutrition, and do they combine these issues with the length of the logistical food supply chain.
2. What are the preferences in food supply and what is the attitude to direct sales.
3. How do consumers perceive the concept of innovative food.

To answer these questions, the research described in the further part of the study was made.

### ***1.1. Eco-innovation and logistics in food economy***

Considering the fact that Poland has undertaken the implementation of the principles of sustainable *development*, apart from taking care of the economic sphere, the care for society and the natural environment is equally important [1]. In the implementation of development, special attention is paid to the issue of innovation as it is seen as a factor of economic growth. The classic definition of innovation states that "Innovation is implementation of a new or significantly improved product (product or service) or process, a new marketing method or a new organizational method in business practice, workplace organization or in relations with the environment" [7]. This definition, also used in directing streams

of financing to support innovations, pays particular attention to the new character of the subject of innovation. In this context, innovations in food economy, and especially in relation to food, may be misinterpreted. It is worth noting that the modern insecticide known as DDT, commonly used in agriculture in the 1940's, after many years turned out to be an extremely dangerous toxin, also for people. In this context, the new character of technology or product cannot be a determinant of innovation in food production. The criterion that should be applied in this sector should focus on the characteristics of the final product or on social and environmental consequences of undertaken actions [6]. This definition of innovation in food economy is considered eco-innovation.

In the light of social and environmental consequences, many economic practices, including agricultural activities, are unsustainable. In the search for innovative food, where a decisive factor for such a classification are the characteristics of the final product such as safety and nutritional value, cultural heritage and traditional knowledge become particularly important. Traditional food production technologies that determine high product quality are marked by innovation [2]. However, to acknowledge this approach, there must be a change in the well-established perception of innovation, and this also involves broader strategic changes. As indicated by Wereszczak [9], strategic changes in Polish agriculture should be based on protection and restoration of natural biodiversity with particular emphasis on probiotechnology combined with development of integrated production, farmers' care for unique natural and cultural values, and agricultural activity must follow the principle of "3xE", i.e. energy efficiency of the agricultural product obtaining processes, economics and ecology.

An important element of food economy is logistics in the supply chain. Customers associate the chain length from the original producer, through processing to the consumer with food quality. They pay attention to both the degree of processing and the complexity of food supplies. The awareness of the importance of logistics in ensuring high-quality food seems on the rise, and education is the key to this growth [5].

In the ongoing globalization process, transnational corporations are gaining importance as thanks to their own economic potential they drive and guide the globalization process. There is strong competition on the Polish market, where local entities collide with the huge and growing potential of transnational corporations. Their advantage is based on technologies, brands, huge and mobile capital, extensive logistics, distribution networks, etc. Their political strength in the form of influence on governments and non-governmental organizations is growing as well, and giants create directions and development trends in food markets. This leads to the formation of oligopolies. This involves subordination and marginalization of local producers' importance [4]. This results in a socially disadvantageous allocation of profits from food economy and externalization of costs run by corporations. At the same time, the impact of food quality on social health is gaining importance [10]. Even higher nutritional value and safety in less

processed food is sought. Shorter logistic chains can be equated with a lower number of cells in processing and storage of food.

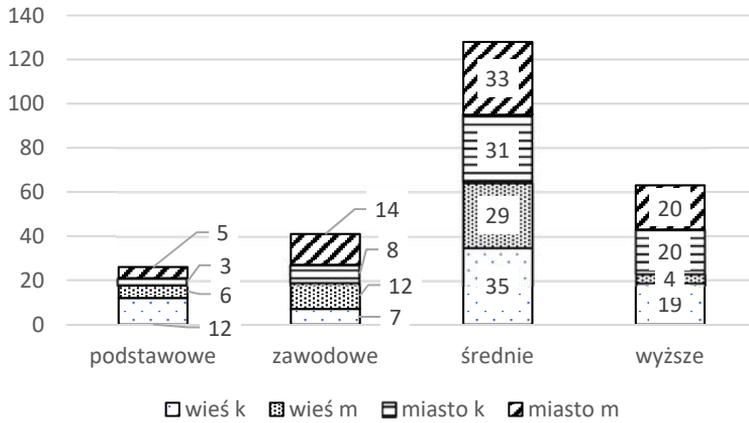
## **2. Material and research methods**

The research was made in 2018 in the Sub-Carpathian Province. The research method was a diagnostic pool, technique - survey, the research tool was a questionnaire. Because the studies were non-probabilistic, the sample was randomly chosen in the number of 300 subjects. After verifying the collected material, there were 258 correctly completed questionnaires.

The research tool was created in the form of a series of formulations, which the respondents had to assess in Likert's five-point scale in terms of their compliance, where 1 meant definitely no, 3 - hard to say, and 5 - definitely yes. One open question was also asked to obtain information on what the respondents consider to be innovative food. The first part of the wording concerned the impact of food on health, preferences and the manner of shopping, preferences regarding food logistics. The intention of the second part was to learn the respondents' willingness to purchase various food products directly from farmers. The collected numerical material was subjected to a cluster analysis, and Ward agglomeration was made. This type of analysis allows separating structures in the collected data and grouping them according to their characteristic features.

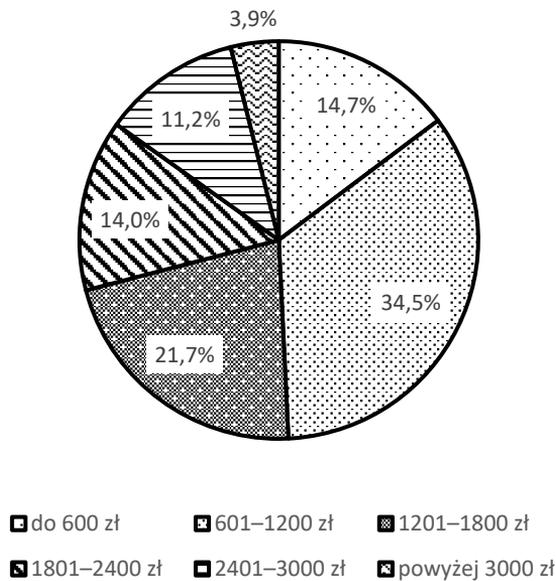
## **3. Analysis of results**

In the surveyed group, there were 52% of women and 48% of men. The structure of education, gender and place of residence in the village/city division is shown in Figure 1. Among all the respondents, almost half (49.6%) had secondary education. The respondents' age was in the range of 13-84 years, the average was 34, the standard deviation was 14.9, the median was 28.5, and the modal was 21, the lower quartile was 22, and the upper 46 years. Figure 2 presents the structure of respondents in terms of monthly income per person in a household. The highest percentage of respondents had income in the range of PLN 601-1200 and PLN 1201-1800 per month per person.



**Fig. 1.** The structure of the respondents broken down by gender, place of residence and education

Source: own research.



**Fig. 2.** The structure of the respondents depending on the monthly income per capita in households

Source: own research.

Fig. 3 presents a dendrogram obtained as a result of the cluster analysis regarding the assessment of food quality phrases, its logistics and preferences regarding the acquisition method. By analysing the graph of the bonding distance relative to the bonding steps, a clear increase in bonding distances occurred at the

value of 30. Hence, after cutting off the dendrogram, four clusters were obtained at this level. The first included wording concerning the impact of food on health, beliefs about the length of the logistics chain and traditional food. The formulation that "food is the main factor in shaping health" was rated the highest and the grades were not very different – the average was 4.31, and the standard deviation was 0.78 (Tab. 1). Thus, people who see the dependence of health on nutrition expect short food supply chains (average rating = 3.94), and see high-quality food in traditional products (average rating = 3.96). This focus also included statements of people convinced of the negative impact of synthetic preservatives and genetically modified food on health.

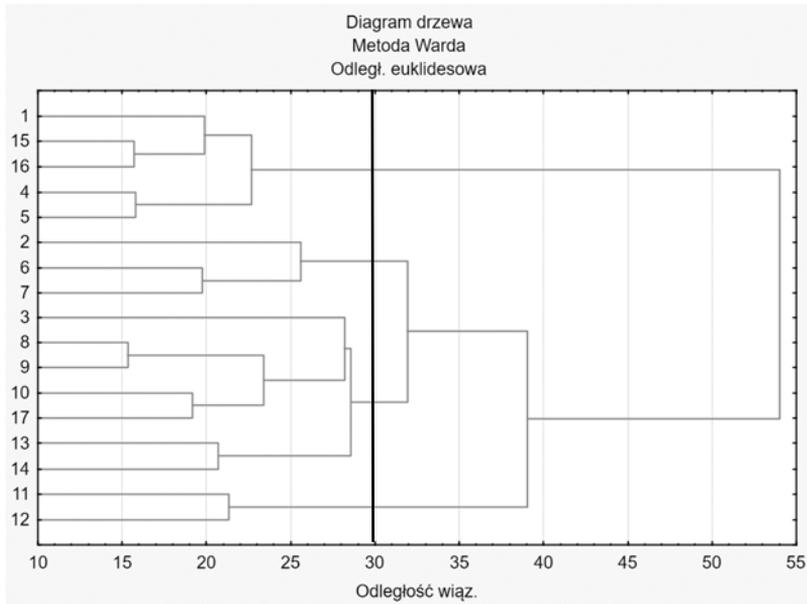
The second cluster combines three issues that can be considered a conscious acquisition. Average answers indicate that the respondents often read labels, sometimes use dietary supplements and do not know the markings of food additives (Fig. 3 and Tab. 1).

The third cluster included a total of 7 phrases which concerned, among others, the assessment of the quality of purchased food, its origin and places of purchase. It is worth mentioning that the tendency to incur higher costs of food quality with sensitivity to its origin combine at a near distance. In both cases, the average grades were close to "rather yes". The willingness to buy directly from farmers was associated with doing most shopping at the bazaar.

The fourth cluster combined the preference of large-area stores with the search for the lowest food prices. However, the average assessment of 2.89 for the "lowest price" suggests that this is not the main criterion for making a choice.

Top-rated phrases included food safety and its impact on health, beliefs of pro-quality factors such as traditional production technology, short supply chain and its origin. The tendency to incur higher purchase costs of high-quality food has also been highly assessed (Tab. 1). It can therefore be concluded that consumers are aware of the key impact of nutrition on their health, and appreciate the high quality of food, as well as declare that the lowest price is not a basic criterion for selection. However, they also acknowledge that they do not know the markings used on labels. Among elements combined in a close cluster, and concerning pro-quality factors, there was a belief of the positive characteristics of short logistic chains therefore it is a suggestion of a strategic nature, motivating to develop this type of logistics.

The study also tried to determine whether consumers would be willing to buy food directly from farmers and, if so, what products would they buy. The analysis of clusters in the part "bonding distance in relation to bonding steps" showed greater distances above 25 (Fig. 4). Hence, after cutting off the dendrogram, five clusters were obtained at this level. They were created in a similar way to the basic division of food into groups. The first cluster was milk and its products, the second included meat and sausages, the third - bread and products such as, for example, pickles or compotes, the next focus was vegetables, fruits and honey. A separate group was alcohol.



1. Food is the main factor in health shaping;
2. I use dietary supplements and vitamins;
3. I rarely eat outside home (in cafeterias, bars, restaurants);
4. Synthetic preservatives and dyes can be harmful to your health;
5. Genetically modified products can cause health problems;
6. I usually read product labels;
7. I know the designation of food additives used;
8. The food I buy is safe;
9. I am satisfied with the quality of the purchased food;
10. Product origin is important to me;
11. The main criterion for food selection is its low price;
12. I prefer food shopping in large-area stores;
13. I do most of food purchases at the bazaar or small stores;
14. I am happy to buy food directly from a farmer;
15. I believe that traditional food provides high biological quality and safety for consumers;
16. A small number of intermediaries (from a farmer to a store) helps to ensure high-quality food;
17. I can pay about 10% more for organic food.

**Fig. 3.** Dendrogram of cluster analysis of the respondents' preferences regarding food quality, its logistics and purchases

*Source: own research.*

**Table 1.** Average and standard deviation of the analysed issues

Wording	Average grade	Standard deviation
1. Food is the main factor in health shaping.	4.31	0.78
4. Synthetic preservatives and dyes can be harmful to your health.	4.24	0.94
5. Genetically modified products can cause health problems.	3.97	1.09
15. I believe that traditional food provides high biological quality and safety for consumers.	3.96	0.85
16. A small number of intermediaries (from a farmer to a store) helps to ensure high-quality food.	3.94	1
17. I can pay about 10% more for organic food.	3.76	0.98
10. Product origin is important to me.	3.57	1.12
9. I am satisfied with the quality of the purchased food.	3.46	0.88
8. The food I buy is safe.	3.38	0.81
3. I rarely eat outside home (in cafeterias, bars, restaurants).	3.24	1.34
12. I prefer food shopping in large-area stores.	3.23	1.09
14. I am happy to buy food directly from a farmer.	3.15	1.19
6. I usually read product labels.	3.12	1.25
2. I use dietary supplements and vitamins.	3.06	1.27
13. I do most of food purchases at the bazaar or small stores.	2.97	1.13
11. The main criterion for food selection is its low price.	2.88	1.13
7. I know the designation of food additives used.	2.81	1.17

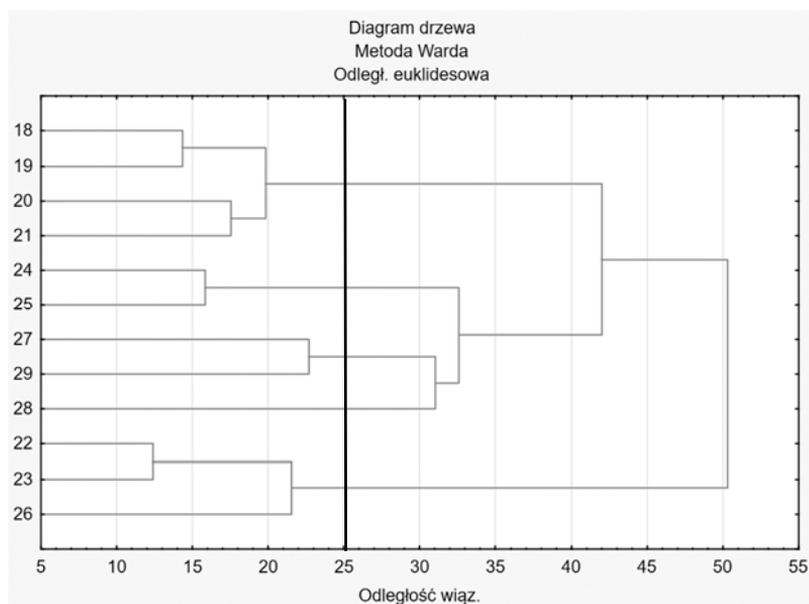
*Source: own research.*

Table 2 presents the average values of the expressed tendency to purchase food directly from farmers. The respondents would buy honey, fruit and vegetables in the direct way most willingly. The highest average values were calculated for these products. It is worth noting that all products except fort alcohol obtained an average of values in the positive range above the value of 3, i.e. lack of conviction. The average value of willingness to buy alcohol was 2.71, which indicates a reluctant attitude to acquire this product in the direct sales system.

These results show that consumers have a generally positive attitude towards buying food directly from farmers but confronting this statement with the results contained in Tab. 2, it can be stated that the respondents do not buy food in the direct system. This issue requires further research in order to develop it.

An important part of the study was understanding the respondents' perception of innovative foods. It is important that the question was formulated so that the respondent understood that it is not about its objective knowledge, but about its subjective belief. Unfortunately, the weakness of surveys is the issue of the respondents' reliability during the survey. However, it is a social study, and unreliability is one of human traits. In this part of the study, among the total number of respondents, 32.2% did not answer the question "What does it mean in your opinion that food is innovative?". This shows that nearly a third of the respondents showed unreliability or misunderstood the question. Answers to this

question were grouped in terms of logic, and the results are shown in Figure 5. Due to the fact that the statements of some respondents were elaborate and ambiguous, the structure of the responses is not summed up to 100%.



- |                |   |
|----------------|---|
| 18. Milk       | 24. Meat  |
| 19. Cream      | 25. Cold cuts   |
| 20. Butter     | 26. Honey   |
| 21. Cheese     | 27. Bread   |
| 22. Vegetables | 28. Alcohols  |
| 23. Fruit      | 29. Preserves (eg compotes, silages, marinades, etc.) |

**Fig. 4.** Dendrogram of cluster analysis of the respondents' preferences regarding food purchases directly from farmers

*Source: own research.*

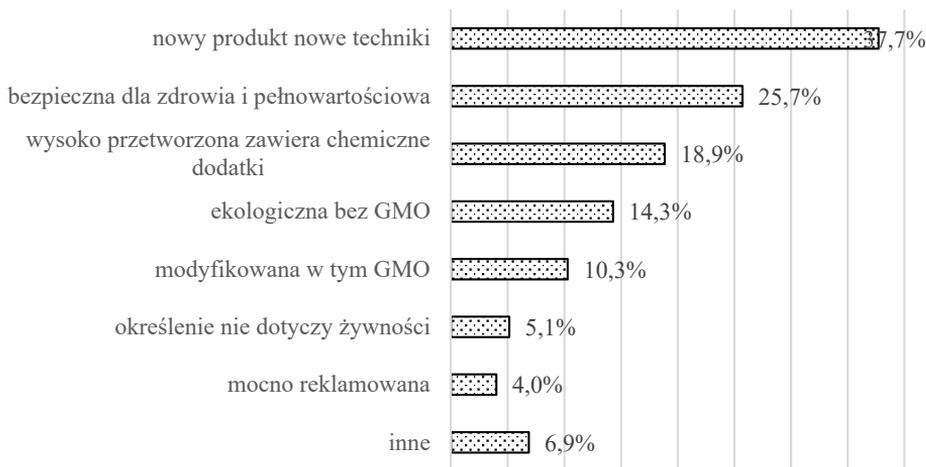
Most frequently, the respondents pointed to the element of new production technology or improvement of the product itself or the method of its delivery to consumers. Nearly 26% of people perceived innovation in the pro-quality impact on the final effect of the production and distribution processes, and 14.3% of people clearly stated that it is organic production without genetic modification. A significant percentage of the respondents associated innovative food with a significant degree of processing and a strong schematic of processing processes, genetic modifications, and this combines with a decline in food quality. About 7% of the respondents pointed to various other features of innovation such as higher price, good designation, creation of new flavours, adaptation to individual needs, higher competitiveness, but also freshness of products, low number of

intermediaries and "following the global trend of being healthy and environmentally friendly".

**Table 2.** Average and standard deviation of the willingness to buy food directly from farmers

Product	Average grade	Standard deviation
26. Honey	4.22	1.07
23. Fruit	3.98	1.20
22. Vegetables	3.95	1.19
29. Preserves (eg. compotes, silages, marinades, etc.)	3.40	1.41
27. Bread	3.35	1.32
25. Cold cuts	3.32	1.30
21. Cheese	3.24	1.34
24. Meat	3.23	1.40
18. Milk	3.11	1.42
19. Cream	3.06	1.39
20. Butter	3.03	1.37
28. Alcohols	2.71	1.41

Source: own research.



**Fig. 5.** The structure of the respondents' definition of the term "innovative food"

Source: own research.

The research shows that the social perception of innovation in the food economy is diversified. Table 3 presents a simple structure of individual

definitions of innovative food, depending on socio-demographic characteristics. Each separate group was treated separately to identify the internal differentiation of the perception of the definition "innovative food".

**Table 3.** Structure of perception of innovative food, depending on socio-demographic characteristics (results in %)

	new product new techniques	modified (GMO included)	ecological without GMOs	highly processed with chemical additives	definition does not apply to food	safe for health and of full value	heavily advertised	other
gender								
woman	28.9	6.6	15.7	15.7	3.3	24.0	1.7	4.1
man	33.0	10.6	6.4	14.9	5.3	17.0	5.3	7.4
education								
basic	33.3	5.6	0.0	22.2	11.1	22.2	5.6	0.0
vocational	25.0	0.0	17.9	10.7	0.0	39.3	3.6	3.6
secondary	34.7	7.9	8.9	13.9	2.0	22.8	3.0	6.9
higher	26.5	13.2	16.2	17.6	7.4	10.3	2.9	5.9
place of residence								
village	31.7	8.9	12.9	9.9	4.0	22.8	5.0	5.0
city up to 10,000 residents	30.8	0.0	7.7	15.4	7.7	30.8	0.0	7.7
city up to 10,000-40,000 residents	26.7	6.7	10.0	20.0	0.0	20.0	6.7	10.0
city above 40,000 residents	31.0	9.9	11.3	21.1	5.6	16.9	0.0	4.2
monthly income per person								
up to PLN 600	35.7	3.6	7.1	17.9	3.6	28.6	0.0	3.6
PLN 601-1200	31.3	6.0	7.2	14.5	3.6	22.9	6.0	8.4
PLN 1201-1800	29.5	11.4	15.9	9.1	2.3	25.0	2.3	4.5
PLN 1801-2400	24.0	12.0	24.0	20.0	0.0	20.0	0.0	0.0
PLN 2401-3000	41.7	0.0	12.5	16.7	12.5	8.3	4.2	4.2
above PLN 3000	9.1	36.4	9.1	27.3	9.1	0.0	0.0	9.1
respondent's age								
<18	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18-30	31.8	6.5	13.1	8.4	3.7	25.2	3.7	7.5
31-60	31.3	12.0	7.2	22.9	6.0	15.7	2.4	2.4
<60	16.7	0.0	8.3	33.3	0.0	33.3	8.3	0.0

Source: own research.

Within all groups separated according to socio-demographic characteristics, the most frequent were definitions referring to new products or new production technologies. Another in terms of frequency was the definition referring to safety and nutritional values. Among people with higher income, living in larger cities, the second statement was the one emphasizing the high degree of processing and

the content of chemical additives. In the groups separated by education, the results were more varied and less explicit. People with vocational education emphasized the safety and value of food more often than the new nature of products. Therefore, the importance of this factor requires in-depth research. As part of the analysis of innovative food perception, respondents were grouped into four age groups. The first to obtain the age of majority, the second is the period of finalizing education and gaining first professional experience, the third corresponds to routine professional work, and the fourth is the period of acquisition of mentoring traits and the senior period (Tab. 3). The group of non-mature respondents was small and everyone emphasized the new nature of innovative food. In the older age groups, apart from the new nature, the safety of such food or a large share of chemical additives were emphasized.

#### 4. Conclusion

Food quality, as the key factor in providing health, requires reliable research and care for its preservation. Ensuring safe and nutritious food for society is a manifestation of care for the vital interest of the nation. It is worth emphasizing that this wording does not bear the signs of pathos, because improper nutrition brings negative consequences on a national scale. Hence, research on the perception of quality traits of food and its determining factors is of great importance.

The conducted research allowed answering the formulated research questions. Several conclusions can be drawn from data analysis.

1. The respondents basically realized the significant impact of nutrition on their health.
2. The surveyed consumers mostly perceived innovations in food production in a manner corresponding to other areas of the economy. The element of novelty in processes, production technology, and the product itself determined the innovation of food.
3. Some consumers were convinced that innovative food is safe, of full value, and produced ecologically without genetic modification.
4. Consumers saw a positive relationship between food quality and short processing and delivery chains.
5. Despite the respondents positive attitude to buying food directly from farmers, a small part of them supplied themselves this way.

In the light of the conducted research, it can be concluded that the perception of food is a phenomenon that can be shaped. To have a positive impact on social health, an educational message, which is not subjected to the pressure of maximizing economic profits but to shape consumers' pro-health attitudes, is important. Considering the fact that health care belongs to the state's tasks, a reliable message about the impact of food on health can be considered an element of health prevention.

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# THE PROSPECT FOR THE USE OF BIODEGRADABLE POLYMERS AS A MODERN AND PROECOLOGICAL PACKAGING MATERIALS

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**Abstract:** The packaging market has great significance on an international scale and packaging production is a powerful branch of industry. However, this industry produces plastics from crude oil, and also generates very large amounts of waste, especially used disposable packaging deposited in landfills. Nowadays, both global politics and leading companies represent holistic approach to the environment. This approach is based on not destroying the natural environment and also saving and renewing natural resources of the Earth. In the light of current trends, packaging made of biodegradable polymers is becoming more and more popular. The paper presents an analysis of the packaging market, including the market of biodegradable polymers, as well as current trends in the policies and example activities of the most important international firms. In addition, biodegradable polymers and their use as packaging materials are described in this manuscript.

**Keywords:** packaging, biodegradable polymers.

## 1. Introduction

Currently, the production of packaging is a branch of industry with a global reach. In 2010, the global packaging market was estimated at GBP 247 billion, and the value of the UK food and drink packaging market alone was estimated at GBP 5 billion. These numbers testify to the great importance of the packaging market on an international scale [1]. However, the use of polymer packaging is accompanied by the production of a large amount of waste. Nowadays, the most important producers on the consumer goods market represent the position of sustainable development. According to the European Commission “Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs”. The aim of the EU Sustainable Development Strategy is to identify and develop actions to enable the EU to achieve a continuous long-term improvement of quality of life through the creation of sustainable communities able to manage and use resources efficiently, able to tap the ecological and social innovation potential of the

economy and in the end able to ensure prosperity, environmental protection and social cohesion [2,3]. In light of current trends leading manufacturers of consumer goods have adopted the position of a holistic approach to the environment, materials, sustainable development and avoid further destruction of the Earth's resources. In 2011, the Unilever group, realizing the plan's assumptions *Sustainable Living Plan* joined the group of producers from the so-called zero landfill groups in the UK: 11 factories do not dispose of any non-classified waste as dangerous. Protect and Gamble has also developed a sustainable development plan *Sustainability Vision*. The company planned to reduce by 2020 the consumption of packaging by 20% and 25% to reduce the use of materials produced from the crude oil. Ultimately, it is planned to manufacture products and packaging exclusively from renewable sources or from recycled materials. The Coca-Cola company has launched an international *Office of Sustainability* that is to integrate initiatives related to sustainable development regarding the protection of water and climate, packaging, recycling and local communities.

In addition to the activities undertaken by companies, international projects are also important to achieving sustainable development. An example of such a project is *Global Packaging Project*. Several leading producers of consumer goods from around the world take part in this project, and its structure is based on work of *European Organisation for Packaging and the Environment*. In 2011, a document *Global Protocol on Packaging Sustainability* was issued as part of this project. The purpose of this document is to help enterprises reduce the environmental impact of packaging by introducing a system of unified concepts covering the basics and calculation methods that relate to a wide range of economic issues related to the sustainable development of packaging [1].

Efficient and economically justified use of packaging materials is an extremely important part of the global holistic approach to the environment. The policy and actions of companies as well as international projects are associated with the global aspiration to save and renew natural resources of the Earth. Contemporary trends in packaging materials include the use of biodegradable polymers and non-environmental processing additives. The advantages of biodegradable plastics include their production from renewable sources, rapid decomposition, as well as the absence of their waste on landfills. The market situation and literature reports indicate a growing interest in the group of biodegradable polymers as packaging materials.

## **2. Biodegradable polymers**

### ***2.1. Biodegradable polymers market***

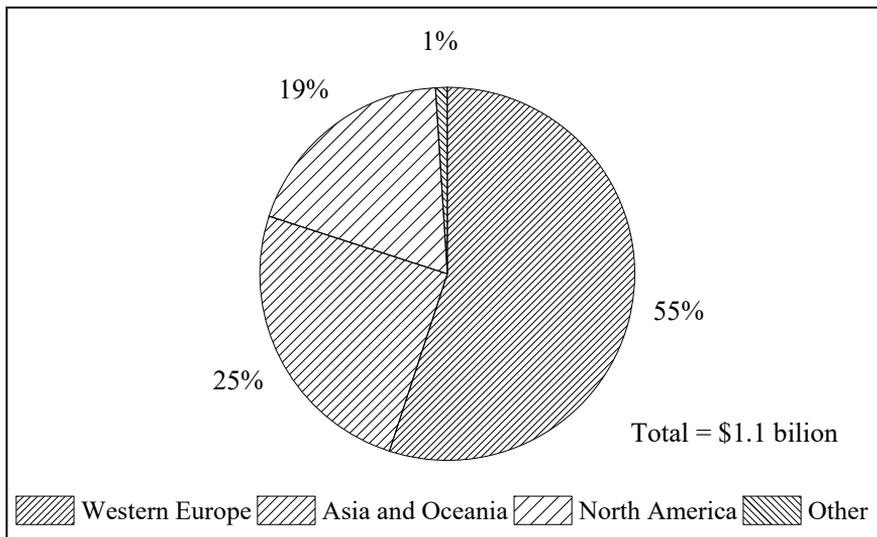
Biodegradable or compostable polymers can be bio-based or fossil-fuel-based polymers (plastics). These polymers decompose, undergo microbial, to carbon dioxide and water in industrial or municipal compost facilities. A few of

biodegradable polymers decompose in backyard composter or in soil, freshwater or saltwater.

A significant application for biodegradable polymers in Western Europe and North America are foam packaging, which includes starch-based loose-fill packaging (packing peanuts), mulch films and other agricultural applications. Smaller-volume markets of biodegradable polymers are paper coatings for cups and cartons, as well as textiles, nonwoven fabrics, resorbable medical devices such as sutures and implants, downhole tools for oil and gas field operations, and 3-D printing filament.

According to new analysis from market research consultancy IHS Markit (*the IHS Markit Chemical Economics Handbook: Biodegradable Polymers Report*), increasing regulations and bans against plastic bags and other single-use plastic items such as drinking straws is driving growing demand for biodegradable plastics. The report says that in 2018 the current market value of biodegradable plastics exceeds \$1.1 billion, but it could reach \$1.7 billion by 2023.

In 2018, global demand for biodegradable polymers is 360,000 metric tons. Total consumption of these polymers is expected to increase to about 550,000 metric tons by 2023, representing an average annual growth rate of 9 percent for the five-year period, which is equivalent to a volume increase of more than 50 percent from 2018 to 2023.



**Fig. 1.** World consumption of biodegradable polymers by region in 2018

Source: IHS Markit [5].

Figure 1 show world consumption of biodegradable polymers by region, in 2018. Western Europe has the strictest and increasingly stringent regulations on disposable plastic. Western Europe commands 55 percent of the global market

value for these polymers, followed by Asia and Oceania (Australia and New Zealand) at 25 percent, then North America at 19 percent of consumption, with the rest of the world combined for less than 1 percent of demand.

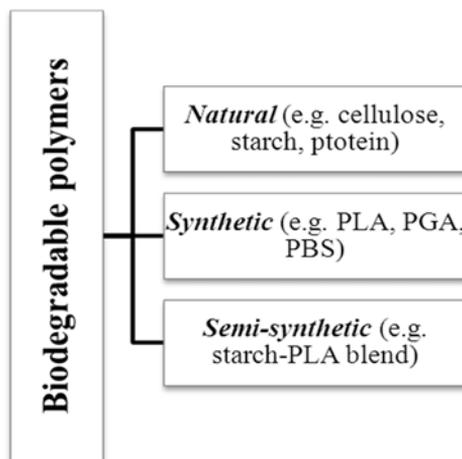
Biodegradable plastics, especially starch-based compounds or polylactic acid (PLA)-based materials, are becoming more and more cost-competitive in comparison to petroleum-based plastics. Demand for these materials is increasing significantly, especially in Western Europe, where environmental regulations are the most stringent. However, the demand for biodegradable plastics is still small, compared to the demand for polyethylene. Legislation is the most important demand driver for biodegradable plastics. As an example of the important role of legislation in driving the market for these polymers can be the limitations in the use of non-biodegradable plastic shopping bags in Italy and France. It has led to a significant increase in the consumption of biodegradable polymers in these countries. Market growth of biodegradable polymers is also affected by the growing environmental awareness of consumers.

However, in order to fully appreciate the advantages of biodegradable polymers and support their use, it is necessary to have adequate infrastructure for their collection and composting. Unfortunately, currently very few large cities and municipalities have adequate infrastructure. Despite the positive potential of biodegradable polymers, the cost of creating the infrastructure necessary to support their collection and composting remains a barrier to the growth in demand of these polymers [4,5,6].

## ***2.2. Type of biodegradable polymers and their application***

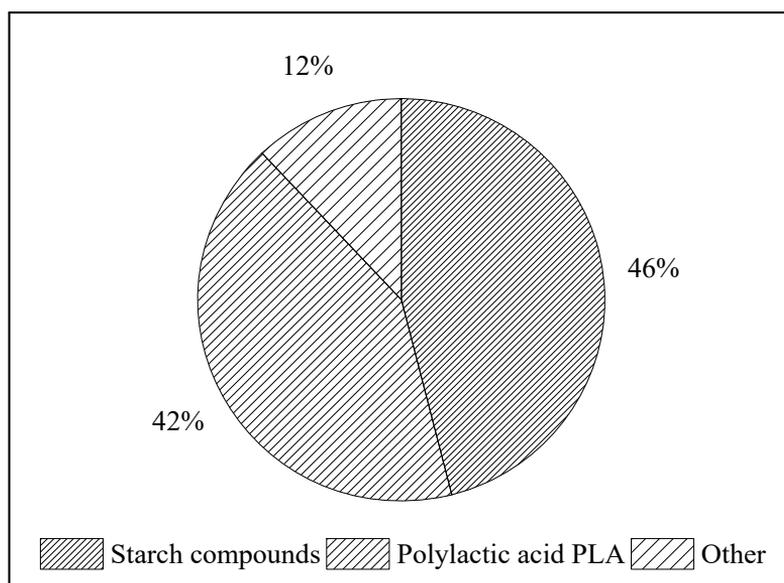
IHS Markit defines biodegradable polymers as bio-based or synthetic polymers that undergo microbial decomposition to carbon dioxide and water in industrial or municipal compost facilities [4,5].

Among the biodegradable polymers can be distinguished polymers of natural, synthetic origin and blends of natural and synthetic polymers. Biodegradable polymers of natural origin are obtained from biomass, while polymers of synthetic origin are produced in chemical syntheses using biodegradable, bio-based monomers (Fig 2.) [7]. The main biodegradable polymers are: polyhydroxyalkanoates (PHAs), including polyhydroxybutyrate (PHB) and related copolymers; polylactic acid (PLA); regenerated cellulose; starch compounds (thermoplastic starch); copolyesters such as polybutylene adipate terephthalate (PBAT) and polybutylene succinate adipate (PBSA); polybutylene succinate (PBS); polycaprolactone (PCL); and polyglycolic acid (PGA) [5].



**Fig. 2.** The categories of biodegradable polymers due to their origin  
*Source: [7].*

The graph below shows the consumption of individual types of biodegradable polymers in 2017 (Fig. 3).



**Fig. 3.** World consumption of biodegradable polymers by type in 2017  
*Source: IHS Markit [5].*

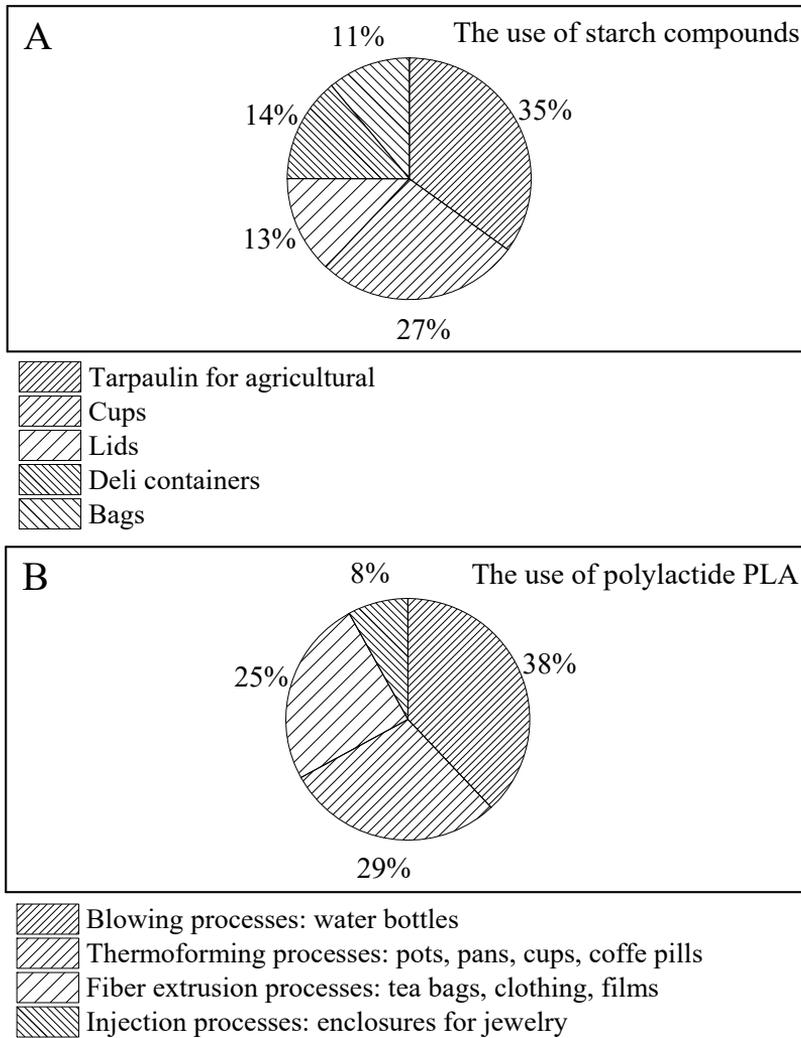
Among the biodegradable polymers, the world's largest consumption was recorded for starch compounds (46%) and for polylactide PLA (42%). Other important biodegradable polymers include copolyesters such as polybutylene

adipate terephthalate (PBAT) and polybutylene succinate adipate (PBSA); polybutylene succinate; polycaprolactone (PCL); cellulose derivatives; polyglycolic acid (PGA); and polyhydroxyalkanoates (PHAs), including polyhydroxybutyrate (PHB) and related polymers [5].

The most commonly used biodegradable polymers are starch compounds. Bio-material starch is one of the most abundant and inexpensive polysaccharide sources. It has perfectly characteristic of biodegradability and to easily dissolve in water. The main source of starch are agricultural plants, such as potatoes, corn, wheat and rice. In plants the starch is produced in the form hydrophilic granules, which consist of amylose (poly- $\alpha$ -1,4-D-glucopyranoside), a linear and crystalline polymer and amylopectin (poly- $\alpha$ -1,4-D glucopyranoside and  $\alpha$ -1,6-D-glucopyranoside), a branched and amorphous polymer [8]. Starch can be used as a filler for commercial polymers (in an amount of 10% to as much as 90%) or it can be transformed into a thermoplastic starch (TPS). Starch can be plasticized through destructureation in the presence of specified amounts of water, heat and then extruded to be used as a thermoplastic [9]. Polystyrene foam packaging can be replaced by foamed starch using steam. These starch can be used to prepared trays or disposable vessels, which dissolve in water, leaving a non-toxic solution, consumed by microbic environment in about 10 days giving only water and carbon dioxide as by-products. The commercial trade names of starch compounds are Biopur<sup>®</sup> (from Biotec GmbH), Eco-Foam<sup>®</sup> (from National Starch & Chemical) and Envirofill<sup>™</sup> (from Norel) [10].

The second biodegradable polymer, in terms of global consumption in 2017, was polylactide PLA. Polylactide is a typical biodegradable synthetic semi-crystalline polyester. It is obtained by ring opening polymerization of lactones [9]. These polyester is made from various natural sources such like tapioca, corn, sugar beets wheat. The D-lactide and L-lactide are two optical forms of polylactide. The L-lactide is natural isomer, whereas the DL-lactide is synthetic blend. Different companies commercialize PLA with various ratios of D/L lactide. Polylactide is sold e.g. with trade names NatureWorks<sup>®</sup> by Cargill Dow and company from USA, Eco plastic<sup>®</sup> of Toyota (Japan) and Biomer<sup>®</sup>L by Biomer company (Germany) [9]. The typical glass transition temperature for commercial PLA is 63.8°C, the elongation at break is 30.7% and the tensile strength is 32.22 MPa. The rate of degradation of PLA is depend on the degree of crystallinity of polymer. The biodegradability of polylactide can be enhanced by grafting. The graft copolymerization of L-lactide onto chitosan was carried out by ring opening polymerization. As the lactide content increases, the degradation of the graft polymer decreases [11].

Both starch compounds and PLA find a wide range of applications. Biodegradable polymers are used extensively in modern society for packaging, agriculture, transport, household utilities (Fig.4) [12].



**Fig. 4.** The use of starch compounds (A) and polylactide (PLA) (B)  
 Source: [12].

### 3. Conclusion

Biodegradable polymers are becoming more and more popular. A very important factor influencing the increase in demand for this type of polymers is legislation. Legal requirements for packaging forcing manufacturers to use more environmentally friendly materials, easy to dispose and consistent with the policy of sustainable development. As a result of such legal actions, the largest leading companies undertake many activities aimed at protecting the environment and resources of the Earth. The strictest and increasingly stringent regulations on

disposable plastic translate into the highest biodegradable polymer consumption in Western Europe. However, the factors blocking the development of demand for these polymers is the competitive, lower price of petrochemical polymers, as well as high cost of creating the infrastructure necessary to support biodegradable polymers collection and composting. Unfortunately, not many cities have such infrastructure.

Among packaging, disposable packaging is particularly controversial. The European Parliament supported the introduction in the EU of a ban on the sale of disposable items, such as plastic cutlery, straws, plates or ear buds. Currently, plastic products account for 70 percent. waste in the sea. The ban on the use and sale of disposable plastic, for which alternatives are available, would apply from 2021. MEPs want 90% by 2021 plastic bottles for beverages were collected separately and recycled. Such practices are already used in some countries. The European Parliament also wants the consumption of plastic products that do not have an alternative to be reduced by 25%. until 2025. It's about polystyrene packaging for burgers, sandwiches, containers for fruits, vegetables, desserts or ice cream [13]. In the light of the introduced law, further development of demand for biodegradable materials can be expected. It seems that the use of biodegradable polymers as packaging will meet stringent standards. In addition, the use of bioplastics is in line with the pro-environmental assumptions of leading companies and the growing environmental awareness of consumers.

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# BIODEGRADABLE AND BIO-BASED THERMOPLASTICS AS SUSTAINABLE MATERIALS FOR PACKAGING PRODUCTION

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**Abstract:** The growing problem with a huge amount of non-biodegradable polymers waste accumulation, especially in aquatic environment, made The European Commission to intervene and prevent this phenomenon. In accordance with the press release of The European Commission entitled “Single-use plastics: New EU rules to reduce marine litter” many disposable products, such as cups, plates, cutlery, bags, straws, balloon sticks as well as many kinds of packaging made of conventional thermoplastics constitute the majority of marine litter. These plastic waste have negative impact on natural environment. They are responsible for destruction of: wildlife, biodiversity and landscape as well. Due to this fact, the non-biodegradable plastics must be replaced by materials which are consonant with sustainability criteria. [1] Moreover, generally applied thermoplastics, like polyethylene (PE), polypropylene (PP), polystyrene (PS) or poly(ethylene terephthalate) (PET) are derived from fossil fuels, so it contributes to irrevocable depletion of such non-renewable resources. Thus there has recently been a huge interest in biomaterials which are not only biodegradable but also bio-based, such as polyhydroxyalkanoates (PHA) and polylactide (PLA) etc. These materials seem to be satisfying substitutes for conventional thermoplastics and may be widely used, especially as packaging materials, which do not have a harmful impact on natural environment contrary to conventional ones. The classification of such eco-friendly materials, including biocomposites and bionanocomposites, their examples as well as advantages are presented in this article. Moreover, some methods of improving mechanical and barrier properties are also described. Finally, some conclusions and future perspectives for entirely eco-friendly materials are mentioned in this paper.

**Keywords:** sustainable, packaging, bioplastics, biocomposites, bio-based, biodegradable, bionanocomposites.

## 1. Introduction

Polymeric materials, including thermoplastics, polyurethanes, thermosets and elastomers are widely applied in a variety of industry sectors. This happens mostly

because of their beneficial properties, such as low cost, resistance to chemical, solar and microbial degradation, thermal and chemically insulating features as well as low weight etc. [2]. Global production of these materials is still growing and in 2016 it amounted to around 335 million tonnes. As can be noticed, this result is higher (by 12 million tonnes) than the previous one achieved in 2015. Only in Europe did total converter demand equal 49,9 million tonnes. Packaging is a main market sector where polymeric materials, including mostly synthesised thermoplastics, such as polyethylene (PE), polypropylene (PP), polystyrene (PS), poly(ethylene terephthalate) (PET) are the most consumed (39,9%). Moreover, the same industry sector is responsible for the largest plastic waste generating-production. About 27,1 million tonnes of plastic post-consumer waste was collected in 2016 only by Europeans [3]. Although the recycling has recently become much more popular waste management method, the problem with accumulating of huge litter amounts from single-use product, such as cups, plates, cutlery, bags, straws, balloon sticks as well as many kinds of packaging made of conventional thermoplastics still exist. The products made of non-biodegradable materials are thrown away shortly after use and become unnecessary ballast on Earth, especially in aquatic environment. These conventional thermoplastics need about from 100 to 1000 years to degrade in natural conditions. During this time, such waste contributes to the death of millions marine organisms every single year. They swallow small pieces of synthetic polymeric materials or are tangled into agglomerations of floating thermoplastics elements [4]. Due to this negative phenomenon, The European Commission decided to significantly restrict the usage of non-biodegradable materials, especially by forbidding the application of them in disposable products [1]. The production of conventional polymers is also related to fossil fuels depletion. Therefore, nowadays there is a large interest in eco-friendly biodegradable materials derived from the natural feedstocks, which can be used as substitutes for non-biodegradable petrochemical thermoplastics, particularly applied in packaging. These materials are definitely consonant with sustainability criteria.

## **2. Biodegradable and bio-based packaging materials**

Nowadays, designing and manufacturing of packaging products must be based on sustainability criteria, which is related to the harmony of economical, social as well as environmental development. It is important especially for life of future generations. Therefore, selected materials for packaging application should be derived from renewable feedstocks ensuring simultaneously durability of these resources. Moreover, environment protection significance of ecosystems and biodiversity must be provided. Furthermore, all activity related to packaging production must not cause toxic gases emission above critical level. It cannot be responsible for irreversible damages in natural environment [5].

Polymeric materials considered as biodegradable are capable of degrading by means of naturally occurring microorganism, such as bacteria, fungi or algae. These polymers are recognised and treated by mentioned microorganisms as resources of organic compounds, like simple monosaccharides or amino acids. They are converted into energy necessary for such organisms to live. Long polymeric chains are transformed into shorter ones as a result of many chemical processes, such as hydrolysis or oxidation in presence of intracellular or extracellular enzymes and other factors. Subsequently, these simple compounds are converted into energy, water, carbon dioxide and biomass by microorganisms. Biodegradable materials are able to fully degrade from several months to a few years. It is much more shorter time in comparison to conventional thermoplastics or other polymeric materials [6]. Biodegradability of materials depends on polymers chemical structure. The origin of materials resource does not play an important role in this process. There are biodegradable materials derived from non-renewable resources, like poly( $\epsilon$ -caprolactone) (PCL) or poly(butylene succinate/adipate) (PBS/A) as well as biodegradable polymers derived from natural feedstocks, such as poly(lactic acid) (PLA) or polyhydroxyalkanoates (PHA) [7].

On the other hand, bio-based polymers are determined as materials derived from renewable carbon resources and the ability of biodegradation is not important. Naturally occurring and produced through photosynthesis components, such as cellulose, hemicellulose lignin or plant oil, are extracted from corn, sugarcane or other biomass [2,7]. Some bio-based polymers can be directly extracted from biomass and can sometimes be modified. The second way of obtaining such material is to synthesize them from bio-derived monomers via polymerization process. The third group of bio-based polymers can be received by natural or genetically modified organisms, which are able to synthesise them [8]. Bio-based polymers can be biodegradable, such as mentioned poly(lactic acid) (PLA) as well as non-biodegradable, like bio-polyethylene (bio-PE) or bio-poly(ethylene terephthalate) (bio-PET) [7].

From the ecological point of view, bio-based and simultaneously biodegradable polymers are the most desirable. These eco-friendly polymers can be divided into three groups depending on the origin of materials resource. The division and examples belonging to selected groups are presented in Table 1 [8].

**Table 1.** Classification of bio-based and simultaneously biodegradable polymers

Category	Description of category	Examples of polymers
I	Polymers extracted or removed from biomass in a direct way.	Polysaccharides (e.g. starch and cellulose) and proteins (e.g. casein and gluten)

II	Polymers obtained via classical chemical synthesis using renewable biobased monomers	e.g. polylactic acid (PLA) (a biopolyester synthesised from lactic acid monomers obtained from feedstock)
III	polymers which can be received by natural or genetically modified organisms which are able to synthesise them	e.g. polyhydroxyalkanoates (PHA), bacterial cellulose

*Source: own elaboration based on [8].*

Materials designed for packaging production, especially ones related to food industry need to comply with strict criteria. First of all, they cannot have a negative impact on human health or life. Moreover, packaging materials shall present antimicrobial function, good mechanical, optical, thermal and aroma barrier properties. The good barrier properties for vapour and gases, like oxygen and carbon dioxide are also required. Furthermore, these polymers should be also relatively resistant to UV [9,10]. The presented polymers can be used as matrices for packaging biomaterials. Nevertheless, many of them have relatively low mechanical and barrier properties which need to be improved. There are some ways to obtain eco-friendly materials for packaging production which present demanded features.

One of the methods to achieve such packaging material with good mechanical and barrier properties is coating. This technique is based on applying an extra thin layer of another compound on the top of selected material. Thanks to this method, some of features, such as oxygen, vapour barrier properties, resistance to oil or grease, mechanical properties, tensile strength and elasticity might be improved. The PLA material coated with a thin layer of AlOx can be presented as an example of biomaterial with boosted barrier properties obtained by this method [11].

Incorporation of some extra additives into bioplastic matrix is another way to acquire bio-based and simultaneously biodegradable material with improved properties. These agents should be bio-based, biodegradable and also safe for natural environment as well as human health or life. There has recently been a significant development of bio-based nanofillers, which can be incorporated into eco-friendly polymeric matrices. These fillers, such as cellulose nanofillers, starch nanofillers or chitin nanofillers can act as reinforcing agents and some of them can also behave like bioactive additives. Bio-based material with such nanofillers exhibit enhanced mechanical, thermal and barrier properties. Boosting of bioactive features, such as anti-microbial activity by some of these nanofillers in some cases can also occur [12]. Presented natural nanofillers and other nanoparticles, such as silica, carbon nanotubes, graphite, nanoclay, metal phosphates, montmorillonite (MMT) or other clay minerals incorporated into polymeric matrices lead to create bionanocomposites. These materials are entirely eco-friendly, biodegradable and exhibit boosted mechanical and barrier properties. Thereby, nanocomposites based on biodegradable polymers derived

from renewable resources have a real chance to become a significant material for packaging production [13]. Besides presented fillers, other additives can be also incorporated into polymeric matrices. Compounds, such as glycerol, propylene glycol, poly(ethylene oxide), sorbitol or water can be presented as examples of agents with ability to decrease brittleness in bioplastics based on proteins or polysaccharides [11]. There has also been increasing interest in natural occurring antioxidants, like flavonoids or carotenoids, which are capable of boosting materials resistance to oxygen activity. Moreover some of these compounds may be applied as natural colorants [14,15].

Some of eco-friendly materials might be also obtained by polymer blending with other bio-based and biodegradable ones. Polymer blend presents different and usually intermediate properties in comparison to pure ones. Thereby, some features can be tailored by choosing proper components in different proportions. Blending can also be a technique to obtain low-cost materials. Respectively cheaper natural biopolymers are able to reduce the cost of more expensive synthesized biodegradable polymers [13]. Some of the chosen polymers can be incompatible to each other. Thereby, addition of compatibilizers is needed for decreasing interfacial energy and stabilizes prepared blends.

Many biocomposites as well as bionanocomposites based on biodegradable polymers derived from renewable resources have been recently designed. They may become important and pro-ecological packaging materials. These biodegradable and bio-based polymeric composites can be categorized into several groups presented in Table 2.

**Table 2.** Classification of the most popular materials obtained from bio-based and simultaneously biodegradable polymers

Groups of packaging materials based on biopolymers	Examples of packaging materials based on biopolymers
packaging materials derived from one type of biopolymer	polysaccharide packaging materials based on starch
	polysaccharide packaging materials based on cellulose
	other polysaccharide packaging materials (based on: chitin, chitosan, pectins)
	protein based packaging materials (derived from wheat gluten, casein, gelatin, corn zein, soy protein and whey protein)
	packaging materials based on polyhydroxyalkanoates (PHA)
packaging materials based on biopolymer blends	packaging materials based on polylactide (PLA)
	packaging materials obtained from starch and polylactide (starch/PLA blends)
	packaging materials obtained from starch and polycaprolactone (starch/PCL blends)
	packaging materials obtained from starch and polyhydroxyalkanoates (starch/PHA blends)

	packaging materials obtained from starch and polybutylene succinate (starch/PBS blends) or derived from starch and polybutylene succinate adipate copolymer (starch/PBSA blends)
	packaging materials obtained from starch and poly(vinyl alcohol) (starch/PVOH blends or starch/PVA blends)
	packaging materials obtained from starch and ethylene-vinyl-alcohol (starch/EVOH)
	packaging materials obtained from another polymeric blends, e.g. chitosan/PVOH blends, PLA/PHA blends, chitosan/PHA blends
packaging materials based on bionanocomposites	bionanocomposites derived from starch
	bionanocomposites derived from cellulose
	bionanocomposites derived from pectins
	bionanocomposites derived from wheat gluten
	bionanocomposites derived from gelatin
	bionanocomposites derived from soy protein
	bionanocomposites derived from polylactide (PLA)
	bionanocomposites derived from polyhydroxyalkanoates (PHA)

*Source: own elaboration based on [13].*

Presented packaging materials obtained from bio-based and simultaneously biodegradable polymers exhibit many advantages in comparison to conventional thermoplastics, which are derived from fossil fuels. Definitely biopolymers are eco-friendly because of the origin. These materials are obtained from completely renewable resources, like biomass, which do not have a negative impact neither on environment nor human life. Contrary to bio-based materials, petrochemical polymers contribute to irrevocable depletion of non-renewable resources. Moreover, the production of polymers, such as poly(vinyl chloride) (PVC) is related to releasing of toxic gases to the atmosphere. Therefore, bio-based materials are definitely more eco-friendly than conventional ones [16].

Another asset of biopolymers concerns shorter degradability time in natural conditions in comparison to widely used thermoplastics, such as polyethylene (PE), polypropylene (PP). Conventional thermoplastics need about from 100 to 1000 years to degrade and in a large part they become ballast on Earth. Particularly it is visible in oceans as well as seas. These materials are also responsible for natural habitats destructions [4]. Bioplastic needs from several months to a few years to convert into simple compounds which is much more shorter time in comparison to non-biodegradable polymers. Moreover, many of these eco-friendly materials are also compostable and are able to degrade in less than 6 months in appropriately selected conditions [6, 17].

Bio-based and simultaneously biodegradable polymers do not have any chemical pollutants. They are entirely free of toxicants. Degradation of such polymers is not related to environment contamination contrary to materials involving toxic additives. Some of the plastics which are able to degrade in aquatic environment in a relatively short term cause chemicals liberating which have harmful impact on animals, plants and also humans [18]. Thus, such eco-friendly materials are entirely safe for humans as well as environment.

Moreover, the production of bioplastics, such as polylactide (PLA) requires lower energy consumption than manufacturing of conventional plastics. It is important from the ecological point of view, because a large part of energy is obtained by fossil fuels combustion and contributes to the increase of carbon polymers lets protect environment from CO<sub>2</sub> emission consequences, like greenhouse effect [19].

Nevertheless, bio-based and simultaneously biodegradable polymers present some drawbacks, such as higher cost than conventional one's related to performance and processing. These issues are challenging and require much more attention [9].

### **3. Conclusions**

There have recently appeared the proposal for a directive of the European Parliament and of the Council on the reduction of the impact of certain plastic products on the environment (COM(2018)0340-C8-0218/2018-2018/0172(COD)) [20]. Due to this fact the need to find the best sustainable substitutes for non-biodegradable materials is even more critical. The choice of the presented biopolymers seems to be a proper solution. These entirely eco-friendly materials are the centre of the researchers attention because of their pro-ecological properties, such as biodegradability, non-toxicity as well as origin from renewable resources. The significant part of experimental work concerning bio-based and biodegradable polymers, such as polylactide (PLA), polyhydroxyalkanoates (PHA) and natural additives, like polyphenols has been conducted in The Institute of Polymer and Dye Technology Lodz University of Technology. There have been also developed researches related to some kind of smart packaging materials based on mentioned aliphatic polyesters. Such bioplastics are able to become prominent packaging materials in the future.

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# THE INFLUENCE OF FINANCIAL PROBLEMS ON THE IMPLEMENTATION OF LOGISTIC PROCESSES IN A PRODUCTION ENTERPRISE – CASE STUDY

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**Abstract:** The article presents issues related to financial problems, which in extreme cases may lead to the loss of financial liquidity. The loss of financial liquidity in a production company and its influence on the implementation of logistic processes in a production company is the subject of the case study mentioned in the text.

The issues of the loss of financial liquidity, which results in turbulence in business contacts with supply chain partners on the one hand with suppliers of raw materials, and on the other hand with recipients of finished products, such as packaging for direct contact with food, in the case described here are the result of decisions made by a company's board of directors regarding both logistic processes of procurement, production and distribution, as well as business contacts throughout the enterprise's supply chain. Financial problems can lead to a decline in income, market shrinking.

The aim of the article is an attempt to analyse the influence of financial problems in a production enterprise on the implementation of logistic processes and actions undertaken by the management to mitigate the effects of the lack of financial liquidity, in particular – the level of customer service. To present the functioning of logistic subsystems in a production enterprise in the conditions of the loss of financial liquidity, the author used the case study. A qualitative research formula was adopted in the research, trying to answer the question of how financial problems affect the implementation of logistic processes under investigation, without addressing the quantitative aspect.

**Key words:** financial problems, financial liquidity, logistic processes.

## 1. Introduction

Financial liquidity is a capability to settle current financial obligations to suppliers of goods, services, also state institutions such as the National Tax Administration or the Social Insurance Company. The lack of financial liquidity causes a drop in banks' trust, suppliers of goods and services withdraw from the trade credit demanding cash settlements, the company loses its reputation [10]. If the growing financial problems are not noticed in time and the company's management does not take appropriate steps, it all will focus on the proverbial "putting out fire" only – there will be disorganization of the company's functioning

manifested by failure to implement the adopted production plans, resulting in failure to meet promised delivery conditions, which may lead to customers leaving the company, market shrinking, and the company's revenue going down. In an extreme case, it can lead to bankruptcy.

Among irregularities in business activity [...], aberration in the treatment of business, money and life, E. Mączyńska mentions, among others [8]:

- too much superficiality, too little sensitivity,
- too much rush, too little reflection,
- too much destruction, too little tradition,
- too much arrogance. too little empathy.

Almost every company has to deal with more or less serious financial problems from time to time. They do not always lead to stopping the economic activity, i.e. bankruptcy, and they can often be overcome [5].

Reasons that can lead to the company's financial problems can be divided into two groups: external reasons independent of the enterprise and internal reasons, which can also be located in the above-mentioned irregularities in management, often leading to the loss of control over the organization.

External causes include [3]:

- phase of the business cycle,
- unpredictable changes in macroeconomic factors,
- adverse changes in interest rates on loans,
- exchange rates,
- financial problems of key recipients as well as suppliers, including withheld supplies.

Among these reasons, there may still be [12]:

- a large client leaving the company for the competition,
- bank's summons to repay the debt,

However, among internal reasons, we find:

- high level of indebtedness,
- decrease in profitability of undertaken operations,
- not using early warning systems,
- hiding information about the financial status
- the company's size.

Internal reasons also include various management deficiencies, including:

- management based on visible numbers only, which does not give full information about the state, threats and the company's capabilities. They concern history, not future, they describe effects, not causes, events, not processes. [...] Instead of dealing with the causes of phenomena, when making decision the management board narrows the area of action only to their effects, it is called hard management culture [15], as well as
- not using the entrepreneurship of employees, their ideas, skills and [knowledge] — they are not listened to [7].

## 2. Financial problems in the functioning of enterprises

The basic problem of an organization functioning in a market economy is keeping financial liquidity, i.e. the ability to timely settle current financial obligations to suppliers of services and goods, as well as state institutions. In the short term, financial liquidity has a decisive impact on the company's duration on the market [10].

Issues of financial problems in the context of an organization such as a production company are inseparably connected with restructuring activities. In this case, restructuring is not about changing the company's strategy – looking for new markets, designing and implementing new products, changing organizational structures. These actions concern the so-called restructuring proceedings that involve restoring the company's ability to settle its current financial obligations and solving debt problems – satisfying creditors' claims.

The most frequently presented definitions of financial problems refer to two spheres: recognition – assessment and a decision-making sphere [3].

Sphere of recognition – assessment:

- lack of ability to pay liabilities,
- excessive level of indebtedness,
- negative financial result,
- bankruptcy or its probability.

In the decision-making sphere, we can distinguish:

- implementation of the adjustment process (restructuring),
- obtaining external financing.

In the company's functioning, there is always the possibility of financial problems, which may result in a decrease in sales, an increase in business running costs, which may lead to a loss of the ability to settle current financial liabilities. This means perturbations in dealing with suppliers of raw materials, materials, commercial goods, utilities, various types of services (transport, maintenance and repair, etc.). Such a state often translates into delays in delivery and incompleteness for existing customers. In a situation when an enterprise operates on the market of commonly available products – products delivered by them do not belong to the niche segment – it must take into account the fact that these problems may be used sooner or later by competitors.

The legal issues of solving financial liquidity problems are regulated by the "Restructuring Law" [11]. This Act contains methods of conduct of an entrepreneur which is an insolvent debtor or in danger of such insolvency.

These methods include the following proceedings [11]:

1. Procedure for arrangement approval.
2. Accelerated arrangement proceedings.
3. Arrangement proceedings.
4. Sanative proceedings.

Depending on the level of indebtedness and the company's current condition, one of the above-mentioned arrangement proceedings may be implemented.

Table 1 gives a brief description of restructuring proceedings and their more important conditions.

**Table 1.** Types of arrangement proceedings and short characteristics

Type of proceedings	Course of proceedings	Comments
Procedure for arrangement approval	Early stage of financial problems. Conclusion of arrangement with creditors. The court approves the arrangement.	The sum of disputable claims entitling to vote on the arrangement is less than 15%. The debtor selects the supervisor of the arrangement and they both sign a contract
Accelerated arrangement proceedings	The court issues a decision on opening the proceedings within 7 days of submitting the application. It enables the debtor to enter into an arrangement after preparing and approving a list of claims in a simplified manner; Making a list of creditors by a court supervisor, preparing and convening a creditors' meeting. Conducting a vote	The sum of disputable claims entitling to vote on the arrangement is less than 15%. About 70% of companies use this type of proceedings The duration of the entire procedure is 3 months, 6 months in reality. The court's appointment of a court supervisor
Arrangement proceedings	Activities the duration of which is prolonged due to ongoing disputes between the debtor and the creditors. The application for the opening of proceedings is analysed within 2 weeks. If a hearing is required within six weeks	The sum of disputable claims entitling to vote on the arrangement is less than 15%. The proceedings last realistically up to 12 months, less effective than the first two. The court's appointment of a court supervisor
Sanation	Proceedings combining bankruptcy and sanation activities. Proceedings for companies in a very bad financial condition. If the arrangement is not signed, the court appoints a bankruptcy estate administrator (trustee).	The court refuses to open the restructuring proceedings if the result of the proceedings would be to harm the creditors and if the debtor's ability to settle the costs of the proceedings and liabilities arising after their opening have not been lent credence. Proceedings lasting 24 months. The court's appointment of an administrator.

*Source: own study based on [11, 14].*

For an entrepreneur who has become insolvent, and the items of his property are sufficient to satisfy creditors, a good solution is bankruptcy with the possibility of concluding an arrangement. However, it is realistic only if there are rational proposals to satisfy creditors, usually combined with reducing at least some of their obligations. However, a necessary condition here is the consensus of the creditors and the debtor. It is also worth remembering that a premise of the arrangement is the debtor's earlier behaviour that guarantees that the arrangement will be executed (Article 14, item 2 of the Act), i.e. – a certain level of reliability and good reputation of the bankrupt [16].

Restructuring proceedings are initiated at the debtor's request.

The SpotData report, Zimmerman Filipiak Restrukturyzacja, contains information and statistics on the course of restructuring in Poland. The report shows that the interest in such proceedings on entrepreneurs' part is growing.

In the first quarter of 2018, an upward trend in the number of opened restructuring proceedings can be noticed. The courts opened 105 restructuring proceedings, 16 more (15%) than a year before. This is due to the increased interest in accelerated arrangement proceedings – by the third quarter of 2017, their number was around 50, and in the first three months of 2018, 60 such proceedings were opened.

Two reasons for the growing number of restructuring can be distinguished.

On the one hand, higher employee and material costs, as well as payment delays make an increasing percentage of entities experience difficulties in settling liabilities - despite the good economic situation. On the other hand, the popularity of the restructuring procedure is growing, and for many companies this is an opportunity to get out of the trap of over-indebtedness more quickly (although it is also often a form of escape from liabilities) [14].

The report does not include entrepreneurs' activities, who, omitting statutory solutions, coped or attempt to cope with financial problems by "getting along" with creditors.

### **3. Characteristics of the studied company and methodology for assessing the implementation of logistic processes**

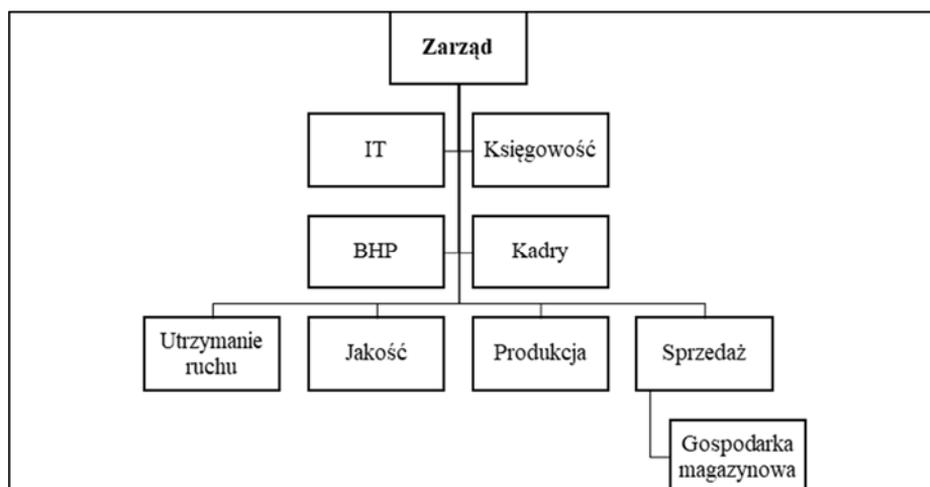
#### **3.1. *Company characteristics***

The company in which the study was made is classified as small- and medium-sized enterprises (SMEs). Below the company's sheet:

- Industry – plastic processing – packaging,
- Year of establishment – 1998,
- Legal form – Limited liability company
- Number of employees – 80-100 employees,
- Capital – Polish,
- Annual turnover – about PLN 24 million,
- Area of activity – Poland, EU.

In the initial period, the company was a daughter company of an American company. It was run by the Americans up until 2010, when it was sold to a Polish entrepreneur. The company operated in a rented post-industrial facility that was not adapted to run a business such as production of plastic packaging. The size of the occupied space and the cubic capacity did not allow to fully meet the requirements of occupational health and safety, as well as fire safety. Additional space for storage of finished products, as well as materials and raw materials, was rented. The Management Board expected expanding the range of manufactured products with technologies not applied so far, as well as a significant increase in the production of the existing products. After two years of operation, the new management board decided to build a new plant in a special economic zone. The investment was completed. The business moved to the new headquarters. The process of changing the location itself, as well as starting production in a new facility, ran without any major disturbances. It should be noted that the demand for the company's products is seasonal, with its peak during the autumn months and the beginning of winter. the remaining period is a considerable drop in consumers' interest, allowing the company to prepare for an increased sales period.

After starting operations in the new location, problems with timely payment settlements appeared, which began to result in difficulties in timely and complete implementation of deliveries for customers. This state has gradually worsen over the past five years. The current lack of financial resources for settling liabilities occurred in its most serious effect, i.e. untimely payment of remuneration to employees. Dawson writes in "Solve every problem" – "If you cannot pay your employees a wage on a Friday, you can close your business on a Monday" [1].



**Fig. 1.** Organizational structure of the examined enterprise

*Source: own study based on the enterprise's materials.*

The company's organizational structure (Fig.1.) is flat, characterized by a low number of management levels which should limit the possibility of personal control and the manager's supervision [6] in the case of large employee teams [13]. In the case of the studied company, this was not the case due to the limited number of organizational units directly responsible for the delivery process, and the only large team was the production department. Such a structure allows for a direct flow of information in both directions, and yet the flow of information encountered many difficulties, especially towards the management – organizational units direction.

Over the past five years, the sales manager has changed five times.

This may have resulted from a low level of the management board's involvement in maintaining communication with the recipients regarding problems in deliveries, leaving it to the "head" of sales staff. Without knowledge of the state of finance, employees were not able to provide accurate information on dates and completeness of deliveries expected by recipients. The most common answer to the question about dates and completeness was: "I do not know". A few significant recipients left. The deepening of financial problems can be traced based on turnover over the last five years. Figure No. 1 illustrates the annual revenue from sales for the years 2013-2015. The drop in sales was marked in 2015, in 2017 the sales were lower year-on-year by 16%. This was caused by subsequent recipients leaving the company, a decrease in production caused by, among others, interruptions in media supplies necessary in the technological process.



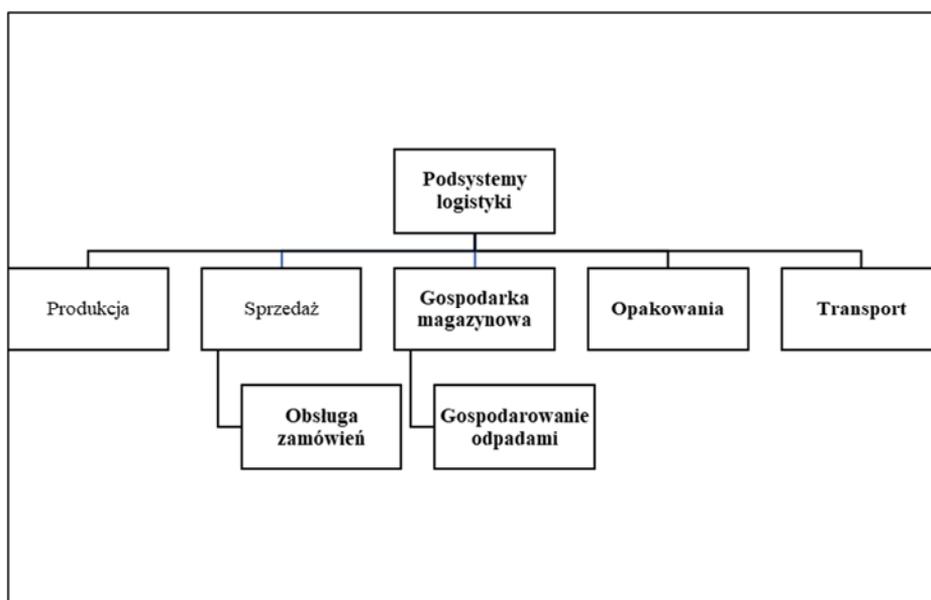
**Fig. 2.** Sales revenues

*Source: own study based on the company's financial reports.*

### 3.2. Methodology for assessment of logistic processes implementation

The main task of logistic processes is the spatio-temporal transformation of characteristics of goods. Pfohl includes transport, storage, packaging and marking in these processes [9]. In addition to these processes that are visible in each organization, there are processes that are only appropriate for a production enterprise, in which, apart from the spatio-temporal transformation, there is a transformation of form, shape, physical and chemical properties that are important for potential buyers.

The figure below shows the company's logistic subsystems that were assessed, in which the financial problems occurring in the company had a noticeable impact on their functioning. It should be emphasized that the logistic processes were assessed for quality, with particular emphasis on the impact on the level of customer service. The study did not deal with the quantitative aspect.



**Fig. 3.** Logistic subsystems

*Source: own study based on [9].*

The enterprise's organizational units and functional areas were analysed based on the division of logistic subsystems presented by Pohl [9] adapted for the needs of this assessment. The following organizational units and logistic subsystems have been identified to conduct tests based on the scheme presented above:

- production,
- order processing – carried out by employees of the sales and production departments,
- warehouse management and waste management,

- packaging – subsystem between production and warehouse management
- transport – especially external.

The assessment of the influence of the lack of financial liquidity on the implementation of logistic processes has been divided into two stages:

1. Identification of the effects caused by financial instability in the studied area of the company's logistics.
2. Identification of activities aimed at mitigating the negative influence of financial instability.

#### **4. Implementation of logistic processes in the enterprise in conditions of financial problems**

Logistic processes in the studied enterprise struggling with financial problems were made according to the company's financial capabilities, as well as the settlement of liabilities. For five consecutive years of intensifying financial problems, all those responsible for a particular area of the company's activity were forced to make choices concerning the use of resources necessary to execute placed orders.

One of the fields on which enterprises compete is the customer service level [2].

Each company, in particular a production company, undertakes three basic activities related to profit generation. It is development, production and sale. Without these activities, the company could not exist [4]. In a situation of permanent financial problems, the company's management made choices regarding the order and volume of liabilities to suppliers. Attempts to expand the market were made, however, this additionally lowered the service level of existing customers due to insufficient resources to increase the production volume.

The lack of organizational units' current knowledge of the possibilities of settling financial obligations to suppliers of materials, raw materials, packaging and services resulted in the inability to implement deliveries accepted for implementation in accordance with the promised conditions. In most cases, liabilities were paid "last minute".

Table 3 illustrates the effects of problems resulting from untimely payment of liabilities directly related to the processes of deliveries to recipients in individual company logistic subsystems.

Based on table 3, the following conclusions are drawn:

- due to the lack of financial liquidity, the costs of running a business increase, and
- the customer service level drops.

**Table 3.** Effects of financial problems in logistic subsystems of the studied enterprise

Order processing	<ul style="list-style-type: none"> <li>– postponing order completion dates to dates later than planned by the client,</li> <li>– failure to maintain the customer service level in the scope of order completeness, as well as compliance of delivery with orders,</li> <li>– making deliveries in the promised period, but incomplete or with replaced parts of the product range, if there is no client's consent to change the date,</li> <li>– the client's resignation from delivery,</li> <li>– the client's resignation from continuing cooperation.</li> </ul>
Production	<ul style="list-style-type: none"> <li>– generating costs related to the need to work overtime due to: <ul style="list-style-type: none"> <li>• lack of basic raw material,</li> <li>• lack of the necessary number of packages and the necessity of the so-called repacking,</li> </ul> </li> <li>– changes in production plans caused by the lack of commercial goods to complement the order volume.</li> </ul>
Warehouse management	<ul style="list-style-type: none"> <li>– the need to change returnable packaging into disposable and vice versa</li> <li>– lengthening the time of delivery preparation,</li> <li>– postponing delivery deadline</li> <li>– delaying deliveries due to the lack of packaging supplies for forming saws. (forming after providing a vehicle) – generating overtime.</li> </ul>
Transport	<ul style="list-style-type: none"> <li>– delays in deliveries caused by delayed vehicle provision.</li> <li>– limiting the number of pallet units due to provision of vehicles with a smaller cubic capacity (33 instead of 38)</li> <li>– blocking the surface of the delivery zone with unaccepted deliveries – extending the loading route of other deliveries.</li> <li>– increase in transport costs due to ordering reduced batches of raw material.</li> </ul>
Packaging	<ul style="list-style-type: none"> <li>– realization of deliveries in non-standard packaging, including more expensive than the ordered ones,</li> <li>– ordering packaging with inferior utility parameters.</li> </ul>
Waste management	Collecting excessive amounts of waste – blocking the release zone surface.

*Source: own study.*

Table 4 includes actions undertaken at the company to mitigate the effects of the lack of financial liquidity.

**Table 4.** Actions mitigating the effects of the lack of financial liquidity in the scope of deliveries

Order processing	<ul style="list-style-type: none"> <li>– giving discounts to compensate for delays in delivery and incompleteness,</li> <li>– issuing invoices in advance of delivery dates (up to two weeks) for factoring-covered customers.</li> </ul>
Production	<ul style="list-style-type: none"> <li>– providing services to one of the largest creditors,</li> <li>– sending employees to unplanned holiday leaves.</li> </ul>
Warehouse management	<ul style="list-style-type: none"> <li>– providing warehouse services for the packaging supplier and sublease of warehouse space</li> <li>– change of Euro returnable packaging into disposable ones for recipients who agreed to it.</li> </ul>
Transport	<ul style="list-style-type: none"> <li>– changing the delivery base as part of INCOTERMS formulas from DDP to FCA for foreign recipients</li> <li>– transferring transport costs to domestic recipients</li> <li>– continuous search for new service providers.</li> </ul>
Packaging	<ul style="list-style-type: none"> <li>– ordering several deliveries for which the payment date for the first delivery does not expire</li> <li>– ordering from a new supplier.</li> <li>– resigning from packaging with company or marketing prints, manipulation and security labels in favour of cheaper ones without prints</li> <li>– ordering packaging with reduced durability</li> <li>– barter exchange of packaging for packaging.</li> </ul>

*Source: own study based on the enterprise's materials.*

## 5. Conclusions

The quoted results of the company's research make it possible to present general conclusions concerning the functioning of a production company in the conditions of financial problems affecting directly the implementation of logistic processes and business management.

1. Financial problems can occur in any enterprise. The management board and company managers should be prepared for such eventuality. The company should have a prepared action plan in case of this type of problems. The process of settling financial obligations must be monitored. This is a condition for making the right decisions in early stages of problems.
2. The implementation of logistic processes in conditions of financial problems and insufficient communication does not allow for a rational use of resources, and maintaining the accepted level of customer service.
3. In the case of the presented problems, the management board did not undertake any actions when the first symptoms of problems related to a timely payment of financial liabilities appeared, assuming an attitude of "we will see how it goes".

4. The enterprise was managed with the use of the hard management culture, meaning it was based on numbers only.
5. Insufficient communication between the management board and persons with specific functions significantly reduced the effectiveness of operational activities - the lack of knowledge of the company's financial situation.
6. The management board was deprived of the influence on counteracting the effects of insolvency through the lack of current information about the company's financial condition.

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# PLASTIC PACKAGING AS A COMPONENT OF CIRCULAR ECONOMY

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**Abstract:** The three basic pillars of circular economy in the field of plastic packaging are implementation of the product life cycle assessment, limiting the waste getting into the environment, educating the public and building appropriate consumer attitudes, both at the stage of conscious purchases and handling of used packaging products. This requires the involvement of both producers and consumers. There are products such as plastic disposable bags, which must or should not be used. But there are products that should be recovered from the market. An example here is the task assigned by the European Union in the form of 90% collection of plastic bottles. The aim of the article is to present the importance of plastics in the implementation of circular economy guidelines.

**Keywords:** packaging, plastics, circular economy.

## 1. Introduction

The 21st century is the time of sustainable growth, i.e. economic and civilization development, which should not take place at the cost of depleting non-renewable resources and destroying the environment. In recent years, more and more attention is paid to problems related to environmental protection and ecology in areas of diversified human activity. There appear slogans referring to the process of environmental degradation as a result of human production activities and significant depletion of natural resources. It is the result of a conflict between civilization progress and technological development [1]. The analysis of the Polish Packaging Chamber shows that in the coming years we should expect a constant growth of the packaging market at a rate of approx. 4.5-6.2%, depending on the packaging type. We should expect that the amount of paper and cardboard packaging will increase (on average 5.5-6.2%), there will also be quite good dynamics of growth of the plastic and metal packaging market (around 5.5%) with a slight advantage of packaging made from synthetic materials. Plastic and metal packaging will deplete the glass packaging market (although here, stable growth is expected at around 4.0-4.5% per year). However, in general we will observe the phenomenon of levelling the share of paper and cardboard packaging with plastic packaging on the packaging market. By 2020, in the market structure, plastic

packaging will occupy the first position (about 38%), the second will belong to paper and cardboard packaging (37%), the next – metal packaging (11%), glass (9%) and other materials (5%) [2].

## 2. Plastic packaging market

Over the past 50 years, the plastics industry has been constantly growing – in the period 1950-2012, the average annual growth was 8.7%. In 2012, global production of plastics reached nearly 288 million tons. The leader in the production of plastics was China (23.9%), the rest of Asia (including Japan) was responsible for 20.7% of world production. Europe's share in global plastics production was 20.4%. Germany constituted approximately 25% of the European market, and together with Italy, France, the United Kingdom, Spain and the Benelux countries they accounted for almost 75% of the total plastics market in the European Union. The countries of Central Europe generated about 14% of plastics in the European Union. Currently, the largest area of use of plastics in Europe is the packaging sector, which is responsible for 39.4% of the total demand for this type of raw material [1]. Plastic packaging is cheaper and lighter than other packaging, and it can be given a variety of properties, such as flexibility, stiffness or softness, and an infinite number of shapes, colours and sizes, depending on customers' needs [3]. For example, people around the world use 500 billion bags a year and the same number of plastic bottles are sold each year [4]. It is estimated that over 70% of waste in seas and oceans are now plastic disposable items, i.e. cutlery, plates, drinking straws, stirrers for drinks or hygienic sticks, all made of plastic.

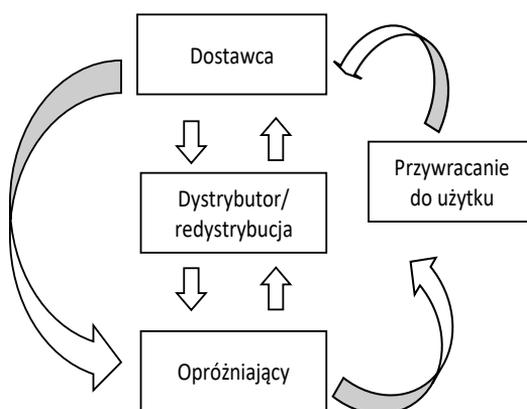
## 3. Circular economy

Sustainable development is an activity that meets the needs of the present generation, without diminishing the opportunities of future generations to meet their needs. Circular economy is based on the fact that the value of products, materials and resources is maintained for as long as possible, and production of waste is kept to a minimum. This approach, firstly, allows avoiding irreversible damage caused by the use of resources at a level that exceeds the Earth's ability to reproduce them, and secondly, makes it possible to increase the competitiveness of the European economy by protecting enterprises against resource scarcity and unstable prices. Circular economy will also contribute to the formation of new, more resource-efficient production methods and consumption patterns [5]. When it comes to packaging, this means that they should be manufactured in a way that allows for their repeated use or recovery, in accordance with specific requirements:

- re-use/multiple use,
- recovery through recycling,

- recovery in the form of energy,
- recovery in the process of composting and biodegradation [6].

In accordance with the principles of circular economy, the management of the life cycle of plastics includes an assessment of their impact on the environment of plastics at every stage, with particular emphasis on the end of the life cycle, where recycling and energy recovery are the main directions for effective management of plastic waste. The circular economy model assumes extending the life cycle through repeated use, repair and recycling. The management of the life cycle of plastics is part of a new management model, as it shows the benefits of the last life stage of plastics, where waste becomes a resource that adds value to a new product [7]. With regard to packaging, the circular system is therefore a system in which the rotation of reusable packaging takes place by a specific entity or a group of enterprises. In order for the circular system to be effective, there must be an organized system of receipt and redistribution of packaging and the filling party/packaging party/retailer is obliged to provide information on how to handle the packaging and the place of receipt for reuse (Fig. 1) [8]. This is important because the European Commission's plans assume a 75% level of recycling of all packaging waste in 2030. At present, this indicator for Poland is 68.5%. Growing heaps of waste (including packaging) on legal and illegal landfills, as well as islands of packaging waste, mostly from plastics, floating in the oceans can be observed. It is therefore an idea to treat these "mountains of waste", which constitute packaging waste, as sources of raw materials and materials. Condition: we have to "pick them out" from these mountains – recover and use. This is a huge task for this sphere of economic activity, which deals with the collection and selection of packaging waste and processing into raw materials for re-use as a result of the recycling process [9].

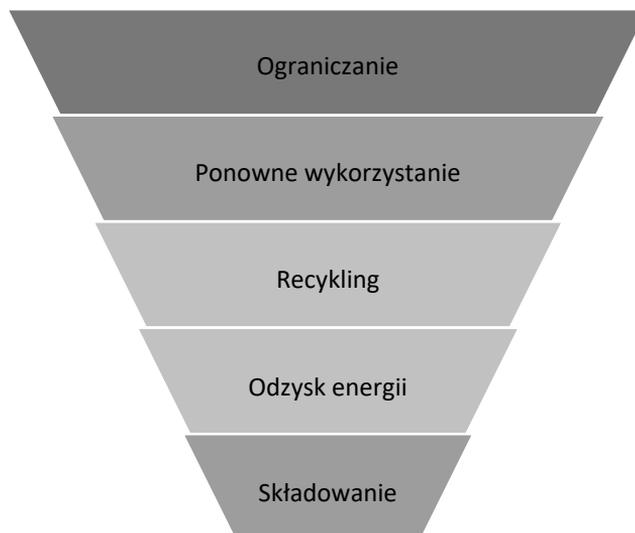


**Fig. 1.** Circular system

Source: Żakowska, 2017.

In the environmental aspect, a disadvantage of plastic packaging is the difficulty of its disposal. Glass and metal are the most sustainable packaging materials among the industry solutions available on the market. They are called permanent, because they do not interact with neither the stored content nor the environment, but their recycling allows obtaining products in the form of new packaging of the same quality as the original one. Therefore, the recycling of permanent materials can, and even should, be carried out indefinitely. A dream of manufacturers of glass and metal packaging is 100% recovery of these products from the market and then their reprocessing [10]. Paper is a natural biopolymer obtained from renewable sources, it can be recycled, and at the end of its life cycle – biodegraded. Paper recycling prolongs its life cycle, reducing raw material consumption, lowering energy use, use of chemicals, reducing water pollution and improving waste management strategies, allowing to reduce the amount of biodegradable waste, incinerated with energy recovery and stored on landfills. Therefore, suitability for recycling is an important element of the life cycle of paper and cardboard packaging [11]. Primary fibres can be recycled about seven times. This process shortens the fibres to such a length that they can no longer be used [6]. Whereas, traditional plastics are practically non-biodegradable, they decompose in the natural environment for many years, while the life cycle of products made from them, especially packaging, is relatively short, as a result of which a huge mass of waste is produced [12]. It is estimated that in 20 years, in relation to 2015, the annual tonnage of global production of plastics will double. Countries have different ways of dealing with the issue of utilization, but even countries with very well-developed infrastructures cannot cope with this problem [4]. Therefore, the focus should be primarily on reducing the amount of plastic waste and, if it is necessary, it must be reused, recycled or converted into energy. The storage of waste is the least needed (Figure 2) [3].

Limiting the amount of packaging should be understood as preventing the creation of packaging "at source", and consists in limiting the weight and volume of individual packaging used in the whole packaging system to the necessary minimum level at which the functions of packaging will be retained. At the same time, packaging design should take into account the possibilities of re-use and subsequent material or organic recycling. Material recycling assumes reprocessing of waste materials and is carried out to manufacture products for the primary purpose or for other purposes [8]. This type of recycling comes after preliminary activities such as segregation, washing and cleaning or preparation for processing [13]. Whereas, organic recycling means the treatment of biodegradable packaging waste. In the case of traditional post-use plastic packaging or multi-material packaging with the participation of plastics, thermal transformation is primarily used to recover energy [8].



**Fig. 2.** Hierarchy of plastic waste management methods

*Source: Frątczak, 2018.*

#### **4. Biodegradable plastic packaging**

In the environmental aspect, a disadvantage of plastic packaging is the difficulty of its disposal. An alternative to traditional plastics may be biodegradable plastics. They are produced from natural or synthetic raw materials. The industrial production of large-scale biodegradable polymer packaging began in 1995. Currently, biopolymers are still niche products but their commercial importance is growing. Their advantage is that they can be collected together with organic waste and composted in industrial installations. The first fully biodegradable and compostable material was thermoplastic starch (TPS). Polymers created based on starch can be obtained from corn, rice or potatoes. They are used for the production of flexible packaging and trays, as well as for coating of printed paper and cardboard. Another material used on an industrial scale is polyactide (PLA). PLA is a biodegradable material obtained from maize grains, it is stiff, resistant to the activity of fats and alcohols, it has low barrier properties towards water vapour, good optical properties, it is easy to print. It is used for the production of milk bottles, edible oils, water and foil. PLA foil packaging decomposes 75-80 days in commercial composting plants [14]. Modern biodegradable packaging materials include the use of renewable biomass every year and carbon-neutral production [15].

Both TPS and PLA are polymers made from renewable raw materials. The second group of biodegradable polymeric materials is petroleum-based polyesters, including: synthetic aliphatic polyester – polycaprolactone (PCL), synthetic and semi-synthetic aliphatic copolyesters (AC) and polyesters (AP), synthetic aliphatic-

aromatic copolyesters (AAC), polymers soluble in water – poly(vinyl alcohol) (PVAL). The division based on the source of raw materials is theoretical, as many companies now use mixtures and combine different types of polymeric materials. It should also be taken into account that as a result of an enormous technological progress, some raw materials, currently of petrochemical origin, may be produced from renewable sources in the near future [16]. Bioplastics are at an early stage of development but the awareness of their importance is rapidly growing, which is accompanied by increased production and more applications. Further development will result in improved properties and reduced prices. At present, compostable plastic packaging is used, for example, to pack food with a short shelf-life [17].

## 5. Conclusions

In times of dynamic development of production and consumption, virtually every activity creates waste (including packaging) that can have a negative effect on the natural environment. Packaging should be constructed in a way so as to protect the packed product, but also to protect the natural environment against its harmful components. Packaging cannot be completely eliminated from everyday life but it should be limited, and if it is necessary, it must be managed rationally after use. This can be achieved through production of packaging from materials that are suitable for processing, use of reusable packaging or use of biodegradable packaging materials that do not contain harmful substances. Governments of individual countries and international organizations must implement guidelines and strive for consistent implementation in this area. In turn, this should lead to a confirmation of the fact that plastic packaging must be part of the concept of sustainable development. However, it is important to build awareness and provide appropriate environmental education on pollution caused by all packaging waste. An important task is to inform the public about the consumption of natural resources, contamination of the air, soil, water or the use of energy. People must be aware that it is necessary to rationalize the use of packaging. Governments and local authorities should watch over the introduction of appropriate legislation that protects both the natural environment and society against the wasteful activities of manufacturers of goods, aiming primarily at increasing profits. Owners of companies and production plants must understand that intensive, rapid development at the expense of the natural environment is a short-sighted policy. Natural resources are shrinking, while environmental pollution is growing at an alarming rate, posing an increasing threat. Everyone should be aware that sustainable development taking place by implementing a circular economy is very important and is not a denial of development. It is a call for prudence and moderation aimed at reconciling areas that are crucial for humanity: economic growth and an even distribution of benefits. The implemented concepts of social business responsibility also in the area of minimizing the quantity and management of waste should be a positive distinction of both a household and a business entity.

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# THE EFFECT OF PACKAGING ON MICROBIOLOGICAL QUALITY OF DRIED FRUIT

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**Abstract:** Dried fruit is gaining more and more popularity among consumers on the Polish market. This is due to its availability, diversity and nutritional recommendations. It is sold in hermetically sealed packaging and by weight. Failure to observe the rules of production hygiene, as well as the consumer's microbiological unawareness, may lead to the transfer of undesirable microflora to a product sold by weight.

The aim of the paperwork was to study the microflora found on dried fruit (plums, apricots, raisins, dates, cranberries, figs) available in stores, and to assess the effect of packaging on the microbiological product quality. Hermetically packaged fruit and fruit sold by weight were tested.

The microbiological analysis included determination of the total number of mesophilic microorganisms, the total number of aerobic bacteria and mould, coagulase-positive bacteria of the *Enterobacteriaceae* family, including *coliform* bacteria, *Salmonella*, and *Shigella*. It was found that bacterial spores and moulds of the *Aspergillus* genus were the dominant microflora that contaminated dried fruit. Based on the results, there were no coagulase-positive staphylococci and *Salmonella* and *Shigella* bacteria. The most contaminated product were raisins and dates. Apricots were the purest product, both those packaged by producers and those sold by weight, similar to cranberries and dried plums. In general, a low level of microbiological contamination of the studied dried fruit and a lower level of contamination of hermetically packaged fruit were found than in those sold by bulk.

**Key words:** dried fruit, microorganisms, packaging.

## 1. Introduction

Dried fruit is gaining more and more popularity not only on the Polish market, but also on the global market. This is due to its condensed content of nutrients, wide availability, possibility of multiple applications, relatively low price and longer storage time without significant quality changes than in the case of fresh fruit. It is the durability of dried products that influenced the faster development of this industry.

Due to the seasonality of fruit production, which does not allow consuming some fruit throughout the year fresh, dried food products are gaining more and more popularity. Also, new dietary recommendations, which focus on the

diversity of meals during the day, contribute to the faster development of this industry.

The microflora present on the fruit is influenced by many factors, such as the climate at the place of cultivation, chemical composition, cultivation method, weather conditions occurring during the growth and maturing process [6]. On the other hand, each type of fruit is an ecological niche in which there are relevant sets of microorganisms changing over time.

The microflora found on fruit usually comes from the air; it is carried by insects and dust floating in the atmosphere. A factor that conditions the adaptation to the conditions prevailing on the surface of the fruit is the formation of defensive mechanisms, such as the production of coloured compounds that protect against UV radiation, and the reduced demand for water and nutrients. On the surface of the fruit are mainly microcosms producing dyes, like mould, and spores resistant to adverse conditions thanks to their structure [1, 2].

The soil, which total microbial contamination can also reach a value of  $10^9$  cells in 1g, has a great effect on the microflora of fruit. Soil is a collection of all physiological groups of microorganisms represented by aerobes and anaerobes, as well as vegetative and persistent forms. The participation of varieties of the *Bacillus*, *Clostridium*, *Pseudomonas*, *Proteus* genus et al., as well as yeasts, filamentous fungi (moulds) and actinomycetes is dominant [5].

Basic primary fruit contamination is a function of the type of plant, environmental vegetation conditions, transport method, storage conditions, etc. Among contaminating forms, there are: yeast belonging to the *Saccharomyces*, Kloecker, *Pichia*, *Hansenula*, *Candida* et al., moulds of the *Penicillium*, *Aspergillus*, *Rhizopus*, *Mucor*, *Fusarium*, *Cladosporium*, *Geotrichum* genus et al., lactic acid bacteria, acetic bacteria and bacteria of the *Bacillus*, *Pseudomonas*, *Proteus* genus that dominate [5]. The primary contamination of fruit can easily multiply due to inadequate raw material storage and improper technological processing. Because the conditions of the drying process are unfavourable for microorganisms (high temperature maintained for a long time), most vegetative forms, especially during logarithmic growth, are lost. However, the process parameters can be withstood by microorganisms that have developed defence mechanisms that make them resistant to high temperatures. An example is bacterial spores, whose high heat resistivity results from their structure and chemical composition [3]. Also, the spores of filamentous fungi and mycotoxins are resistant to high temperatures [7].

The aim of the study was to assess the microbiological status of dried fruit available on the market and to determine the impact of packaging on the microbiological quality of these products.

## 2. Material and methods

The study involved 6 dried fruit available for sale in hermetic packaging and by weight. The description of the tested products is presented in Table 1 (hermetically packaged dried fruit) and in Table 2 (dried fruit sold by weight).

**Table 1.** Hermetically packaged dried fruit

Research material	Photo	Description on packaging
Plums		Dried plums without seeds Preservative: E202 – potassium sorbate Country of origin: Chile
Apricots		Dried apricots without seeds Composition: Dried apricots without seeds, preservative: E220 – sulphur dioxide Country of origin: Turkey
Raisins		Sultan raisins. Composition: Sultan raisins (99.5%), cotton and/or sunflower oil Country of origin: Turkey
Dates		Dates without seeds. Country of origin: Pakistan
Cranberry		Cranberry, sweetened, dried, whole fruits Ingredients: cranberry (51%), sugar, sunflower oil Country of origin: USA
Figs		Dried figs Country of origin: Turkey

*Source: own elaboration.*

**Table 2.** Dried fruits sold by weight

Product	Picture	Description
Plums		Composition: plums, potassium sorbate Country of origin: Chile
Apricots		Composition: dried apricots, preservative: Sulphur dioxide Country of origin: Turkey
Raisins		Composition: Raisins, sunflower oil, preservative: sulphur dioxide Country of origin: Chile
Dates		Composition: dates Country of origin: Iran
Cranberry		Composition: dried cranberry 55%, cane sugar 44.5%, sunflower oil Country of origin: USA
Figs		Composition: dried figs, preservative: sulphur dioxide Country of origin: Turkey

Source: own elaboraton.

The microbiological analysis of dried fruit included the definition of:

- the total number of mesophilic microorganisms (on PCA medium),
- the total number of oxygen sparing bacteria (on the PCA medium after subjecting the sample to the so-called thermal shock),
- microorganisms of the *Enterobacteriaceae* family (on the VRBG medium),
- *coliforms* and  $\beta$ -glucuronidase positive *Escherichia coli* (on the Chromocult<sup>®</sup> TBX medium),
- *Salmonella* and *Shigella bacteria* (on the SS medium),
- number of coagulase-positive staphylococci (on the Baird-Parker's medium),
- number of filamentous fungi (on the Sabouraud substrate).

10-fold dilutions of the analysed samples were prepared and then cultured on Petri plates. Microbiological tests were conducted using the culture method in accordance with PN-EN ISO standards.

The identification of filamentous fungi was based on macroscopic observations of growth observations in plate cultures and based on microscopic observations.

### 3. Results and discussion

Based on the obtained results (Table 3), a diverse number of bacteria, both mesophilic and sporulating were found in the analysed dried fruit. The total number of mesophilic bacteria present in packaged fruit was from  $1,1 \times 10^2$  to  $3,1 \times 10^8$  cfu/g. The total number of mesophilic bacteria present in fruit sold by weight was from  $2,8 \times 10^2$  to  $1,4 \times 10^9$  cfu/g. The highest number of bacteria was found in raisins sold by weight ( $1,4 \times 10^9$  cfu/g), and the lowest in dates sold in hermetic packaging ( $1,1 \times 10^2$  cfu/g). A comparable number of mesophilic bacteria was found in fruit bought by weight, such as figs and cranberries. However, some fruit (plums, apricots and raisins) sold by weight had a high number of mesophilic bacteria compared to hermetically packaged dried fruit.

Sporulating aerobic bacteria was not present in plums, apricots, cranberries in both hermetic packaging and sold by weight. In the remaining fruit, the number of sporulating aerobic bacteria was not high and varied from  $1,1 \times 10^1$  to  $1,5 \times 10^2$  cfu/g.

**Table 3.** Total number of mesophilic and sporulating microorganisms

Product		Number of microorganisms [cfu/g]	
		mesophilic	sporulating
Plums	packaged	$3,6 \times 10^4$	Nb
	By weight	$1,8 \times 10^5$	Nb
Apricots	packaged	$7,8 \times 10^3$	Nb
	By weight	$1,4 \times 10^5$	Nb
Raisins	packaged	$3,1 \times 10^8$	$1,4 \times 10^1$
	By weight	$1,4 \times 10^9$	$1,5 \times 10^2$
Dates	packaged	$1,1 \times 10^2$	$1,5 \times 10^1$
	By weight	$5,3 \times 10^4$	$1,8 \times 10^2$
Cranberry	packaged	$4,0 \times 10^3$	Nb
	By weight	$3,5 \times 10^3$	Nb
Figs	packaged	$2,8 \times 10^2$	$1,1 \times 10^1$
	By weight	$2,8 \times 10^2$	$1,7 \times 10^2$

Nb – absent in 10 g

Source: own elaboraton.

Dried fruit sold in stores is often contaminated with mesophilic microorganisms. The primary contamination of fruit can easily multiply due to inadequate raw material storage and improper technological processing. Because the conditions of the drying process are unfavourable for microorganisms (high temperature maintained for a long time), most vegetative forms, especially during logarithmic growth, are lost. However, the process parameters can be withstood

by microorganisms that have developed defence mechanisms that make them resistant to high temperatures. An example is bacterial spores, whose high heat resistivity results from their structure and chemical composition. While vegetative cells die after 10 minutes of heating at 80°C, endospores can withstand even hours of heating. In their structure they contain up to 15% water and dipicolinic acid the complexes with calcium ions of which allow them to survive the drying process [4].

The total number of *Enterobacteriaceae* present in fruit sold by weight was from  $2,3 \times 10^1$  to  $1,7 \times 10^3$  cfu/g. The highest number of bacteria was found in raisins sold by weight, and the lowest in hermetically packaged apricots. Bacteria of the *Enterobacteriaceae* family was not detected in dried fruit sold in packaging, such as dates, cranberries and figs. However, some fruit (plums, apricots and raisins) sold by weight had a high number of bacteria of the *Enterobacteriaceae* family compared to hermetically packaged fruit (Table 4). The only product in which *coliforms* were present were figs sold by weight. The number of this bacteria in figs by weight was low and amounted to  $1,0 \times 10^1$  cfu/g.

The main source of secondary pollution of dried fruits is man. We have a rich microflora on our skin and in the digestive tract. It was man who could be the reason for the presence of bacteria from the *Enterobacteriaceae* family in the analysed products.

**Table 4.** The number of microorganisms from the *Enterobacteriaceae* family and from the *coli* group

Product		Number of microorganisms [cfu/g]	
		from <i>Enterobacteriaceae</i>	from <i>coli</i>
Plums	packaged	$2,3 \times 10^1$	Nb
	By weight	$5,2 \times 10^2$	Nb
Apricots	packaged	$4,5 \times 10^1$	Nb
	By weight	$1,4 \times 10^2$	Nb
Raisins	packaged	$1,0 \times 10^2$	Nb
	By weight	$1,7 \times 10^3$	Nb
Dates	packaged	Nb	Nb
	By weight	$2,1 \times 10^1$	Nb
Cranberry	packaged	Nb	Nb
	By weight	$3,8 \times 10^1$	Nb
Figs	packaged	Nb	Nb
	By weight	$3,6 \times 10^1$	$1,0 \times 10^1$

Nb – absent in 10 g

Source: own elaboraton.

None of the tested products (plums, apricots, raisins, dates, cranberries and figs), sold both in hermetically sealed containers and by weight, were contaminated with *Salmonella* and *Shigella* bacteria and coagulase-positive staphylococci.

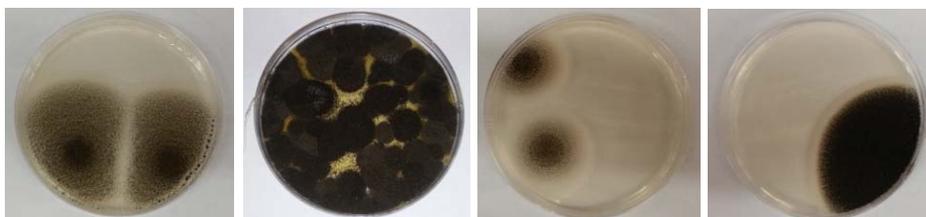
The number of filamentous fungi present in the packaged fruit is from  $1,3 \times 10^1$  to  $5,0 \times 10^2$  cfu/g, and in the fruit sold by weight from  $2,8 \times 10^2$  to  $4,8 \times 10^3$  cfu/g. However, some fruit (plums, apricots and raisins) sold by weight had a high number of filamentous fungi compared to hermetically packaged fruit (Table 5). However, analysing which filamentous fungi were on the fruit based on macroscopic and microscopic observations, it was found they belong to the *Aspergillus* genus and the *Rhizopus* genus (Table 5, Figure 1-2).

**Table 5.** Number of filamentous fungi

Product		Number of filamentous fungi [cfu/g]	Morphological identification
Plums	packaged	Nb	-
	By weight	Nb	-
Apricots	packaged	$1,3 \times 10^1$	<i>Aspergillus</i>
	By weight	$3,8 \times 10^2$	<i>Aspergillus</i>
Raisins	packaged	$5,0 \times 10^2$	<i>Aspergillus</i>
	By weight	$4,8 \times 10^3$	<i>Aspergillus</i>
Dates	packaged	$5,6 \times 10^1$	<i>Aspergillus</i>
	By weight	$2,8 \times 10^2$	<i>Rhizopus</i>
Cranberry	packaged	Nb	-
	By weight	Nb	-
Figs	packaged	Nb	-
	By weight	Nb	-

Nb – absent in 10 g

Source: own elaboraton.



**Fig. 1.** The growth of filamentous fungi on the Sabouraud medium

Source: own elaboraton.



**Fig. 2.** Morphology of selected filamentous fungi (microscopic observations, x40)

*Source: own elaboraton.*

#### 4. Conclusion

Based on the microbiological analysis, it was found that bacterial spores and moulds of the *Aspergillus* genus were the dominant microflora that contaminated dried fruit. There were no coagulase-positive staphylococci and *Salmonella* and *Shigella* bacteria. The most contaminated product were raisins and dates. Apricots were the purest product, both those packaged by producers and those sold by weight, similar to cranberries and dried plums. In general, a low level of microbiological contamination of the studied dried fruit and a lower level of contamination of hermetically packaged fruit were found than in those sold by bulk.

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# INTELLIGENCE IP RIGHT – RESUME BEST PRACTICE

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**Abstract:** This paper gives a typical analysis about the intelligence IP rights in logistics industry, that it can, in a proper logistic scope, reduce the cost effectively and shorten the logistics time to optimize the effectiveness of the logistics. Advantages of the BI technology are: the possibility of an intuitive, accurate reporting; less time of submission of the report, possibility to report submission in different formats and to different users, the possibility of integration of the BI applications with a variety of ERP systems, development of the BI applications for various management levels of the business system etc.

**Keywords:** Intelligence IP right, Industry 4.0., copyright, model, information.

## 1. Introduction

Intellectual property rights are the rights given to persons with respect to creations of their minds. They usually give the creator an exclusive right over the use of his/her creation for a certain period of time. It is a right of a person or a company to have exclusive rights to use its ideas, own plans, or other intangible assets without the worry about competition, for a specific period of time. These rights can include trademarks, patents, copyrights, and trade secrets. These rights can be enforced by a judicial body with help of a lawsuit. The intellectual property encourage innovation without fear that a competitor will steal and/ or take the credit for it. Register intellectual property right of owner in the country (not company) must be done immediately. It is one of the fundamental legislation to be competitive in the business or to represent a high value brand company (know-how).

Intellectual property now have many definitions, taking in to consideration protection of Intellectual Property it is limited by time. For instance, the typical period of invention protection is 20 years. Protection of property rights of copyright objects is invalid during the author's life and additionally 70 years after his death. However the personal moral (non-property) rights of the author are protected for an unlimited term. Polish system law is in line with all key

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international IP arrangements: Poland is a WIPO member and most notably a signatory of the Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS), the Berne Convention. As a member of The European Union, is also obliged to maintain compliance with overriding European IP<sup>3</sup> regulations. Internally, a fundamental part of IP law is contained in the following statutory acts:

- 1) Copyright and Related Rights Act,
- 2) Industrial Property Law Act,
- 3) Database Protection Act.

Intellectual property rights are customarily divided into main areas:

### **1.1. Copyright and rights related to copyright:**

*The specific purpose of protection of copyright and related rights is to encourage and reward creative work. Also protected through copyright and related rights are the rights of performers (e.g. actors, singers and musicians), producers of phonograms (sound recordings) and broadcasting organizations.*

### **1.2. Industrial property:**

Industrial property can be divided into two main areas. One of the area can be characterized, in particular trademarks and geography as the protection of distinctive signs. It aims to ensure fair competition and protect consumers rights, by assisting them to make informed choices between various goods and services. Other types of industrial property are protected primarily for creation of technology and design stimulate innovation, the. In this category fall trade secrets and industrial designs. The important purpose is to provide protection for the results of investment in the development of new technology, thus giving the means to finance research incentive, and development activity.

### **1.3. Intellectual Property – a tradable value**

Originally, patents were considered as only providing rights for prohibition and exclusion. Increasingly, however, they have been gaining importance<sup>4</sup> as intangible assets. Trade in patents is an integral part of today's financial world.

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<sup>3</sup> Directive 2016/943/UE to the protection know-how 6/6/2018

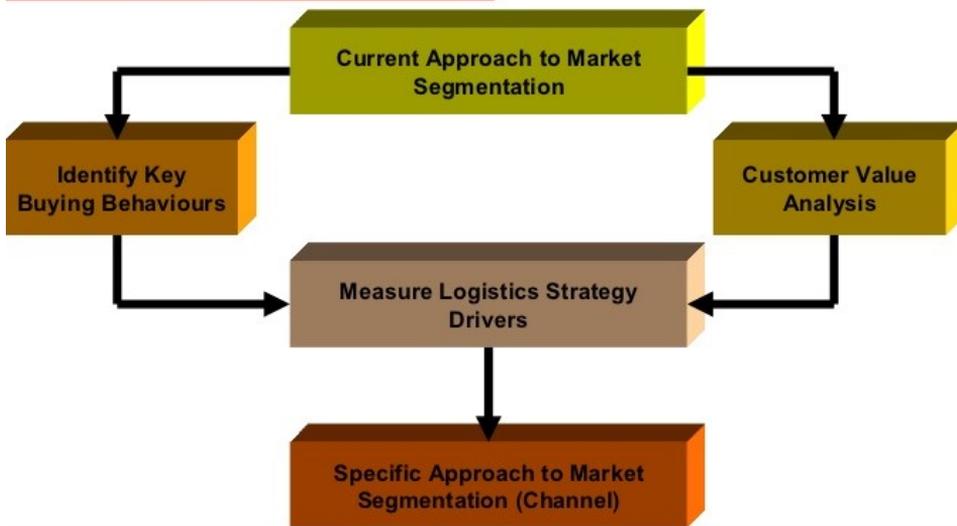
<sup>4</sup> Oueslati, W., Akaichi, J., 2010. *A Survey on Data Warehouse Evolution*, International Journal of Database Management, Vol. 2(4), pp. 11-24.

### 1.4. Untapped potential – the sleeping patent

Despite the sharp rise in the importance of patent trade and licensing models, at present many patents remain undervalued or even not valued at all.<sup>5</sup> on the basis of the value of patents in Europe, one third of patents in the EU are not used effectively for economic gain. Patent exploitation companies strive to identify and utilise this hidden potential.

Intellectual property, Intellectual capital, and “Knowledge economy” brought several changes in various areas. Thanks to new technology, communication and new economy imposed are new rules, new content, new dimensions and new knowledge. It is not possible to apply the previous paradigms of comparative advantages based on the available natural resources, labour and capital. The industrial age has been replaced by the age of the modern economy, which is also known as the “knowledge age”. Today, globalization process, imposed new challenges in the process of creating and maintaining competitiveness.

## Logistics – Approach / Framework



**Fig. 1.** Framework for logistics

Source: <https://www.slideshare.net/anandsubramaniam/logistics-management-1557110>

There must be judicial law in company to take final decisions about skills of the workers. We know that Kaizen has many procedure that same ISO regulation.

<sup>5</sup> Kimball R., Ross M., Thornthwaite W., Mundy J., Becker B., 2008. The Data Warehouse Lifecycle Toolkit, John Wiley & Sons, January 10, 2008.

In case a worker needed take responsibility that table informed what knowledge he/she must have.

Today competitive advantage is important for the success of any company in the global market. In modern economy foundations competitiveness is located in the high technologies, knowledge and innovation, global connectivity and strategic pooling. All companies, today are struggling to find sources of competitive advantage, which will make financial and other performance better. knowledge and innovation will help to achieve the goal better than others, and it can be achieved by the market value of every modern company consists of the financial capital and Intellectual Capital.

## 2. Literature review

The way IPR is protected from one nationality to another varies to a large extent. IPR protection represents a transaction between the profits of innovation and the superiority cost. The protection of IPR is always restricted in the length or scope of protection.

Intellectual property was introduced to protect the labours of the mind, production and man's own. In the late 19th century, with the introduction of high technological progress, Intellectual property transactions started together with the creation and development. However, contradiction between the global demand for IPR and regional restrictions exist. To solve this contradiction, number of countries have bound themselves with the International Convention for the protection of their Intellectual properties.

Both developed and developing countries adopted IPR to stop counterfeiting and piracy. It has been discovered that IPR decreases the income of industries that depend on products imitation of developed countries and the increase in the costs of protected goods and thereby strengthening of IPR protection in developing countries contribute towards profit maximisation for the developed nations<sup>6</sup>.

Strengthening IPR will encourage more innovation to the global economy, hence promoting rapid economic intensification. Moreover, although supplementary novelty is mostly intense in advanced countries, reinforcement of IPR will speed up the technology transfer between countries, thus ensuring benefit of all countries.

It can be said that without the implementation of IPR, the innovation cost and the product development would not have increased its benefits. Technological transfer from foreign firms in developed countries can be a significant resource for firms in developing nations. The impact of stronger IPR protection depends on a country's present circumstance. IPR has encourages the transfer of technology by increasing trade of goods and services. It has been found that efficient

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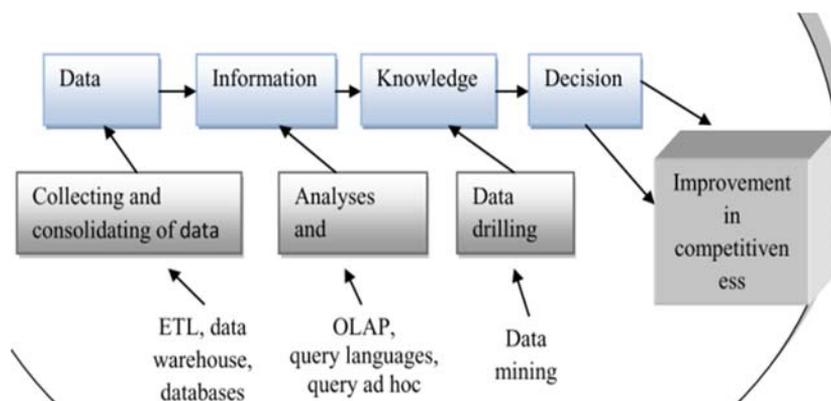
<sup>6</sup> E. William Cowell and Jeffrey H. Reed, (2017), *Intellectual Property and Universities: A Path Forward, Proceedings of the IEEE*, 105, 7, (1195).

protection of IPR encourages the transfer of technology through several channels; however impact depends hugely on the development capability of a country.

Legislations are been put into practice to protect consumers from dishonest marketers who in the name of IPR they exploit consumers by false advertising, misleading packaging and marketing of unsafe products.

### 3. BUSINESS INTELLIGENCE MODEL

Business Intelligence transform raw data into meaningful and useful information and knowledge. BI provides business information and the analysis of key business processes, quality decision-making at different management levels and improvement of the performance in the business system. The role of BI in the process of decision making is shown in Figure 2.



**Fig. 2.** BI Structure

Source: <http://www.skillsfuture.sg/-/media/Initiatives/Files/SF-for-Logistics/Occupation/5-Intellectual-Property-IP-Management.pdf?la=en>. 6/6/2018

The development of information technology – IT has enabled the development of modern platforms to help work with large amounts of data. On one hand, the volume of data being generated and stored in business systems is constantly growing, and on the other hand, there is an increasing number of users and their needs for high-quality information and new knowledge. BI meets the requirements of business systems because it can get information quickly, reliably and in an appropriate form.

The BI system can be observed from different angles. The BI system allows the transformation of data into information and knowledge, thus creating new conditions for decision-making in the business system. The real value of the BI system is reflected in the added value that is generated: better understanding of one's own resources, the implementation of changes in the business system, and new markets, etc.

In almost all business systems there are developed reporting systems that are based on traditional approaches and are a standard part of the IS and ERP systems. These reports are usually standard, historical and static.

BI enables overcoming of these problems and provides new opportunities to business systems in the context of fast market changes. BI includes all activities and business processes, along with in order to transform them into reliable and quality information providing timely response to business issues. The right information at the right time and the right place is a prerequisite for making decisions at the operational, tactical and strategic level, and quality decision-making leads to the creation of additional value in the business system. BI is a modern and contemporary approach to the monitoring of the business system, which requires specific hardware and software infrastructure and the DWH system. The important component of BI technologies are reporting and analytics, which, on the modern IT platform, got new possibilities in terms of application of analytical and statistical models, BI application integration with other business systems and the possibility of different forms of presentation.

“The BI system consists of a number of applications that are designed for analytics and reporting on certain processes, performances, causal relationships that exist between different parts of the system or are created according to specific customer requirements.

The use of these applications can indicate the performance of the process and of the entire system, the analysis of deviations and proposal of measures that lead to improving productivity. BI has the ability to connect with number of operations and improvement of business performance are *how is it done now* and *why*, and *how it should be done*. The answers to these questions have a direct impact on the future way of doing business. BI allows monitoring and management of the business system through different types of applications that provide an immediate response to the user on the state of business processes and activities”<sup>7</sup>.

The above paragraph explains the broad application of Business Intelligence in logistic process and represent the process to be included in logistics IP right for each company.

## 4. Types of Intellectual Properties and their Description

### 4.1. IPR enhances technology advancement ways:

- 1) it provides a mechanism of handling, piracy, and unauthorized use,
- 2) it provides a pool of information to the general public since all forms of IP are published except in case of trade secrets.

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<sup>7</sup> On collaboration inspiration article Mu Lina, Xiao Shengling. Discussion on the Application of Business Intelligence in the Logistics [J]. Forest Engineering, 2007(5): 90-92.

#### **4.2. IP protection can be sought for a variety of intellectual efforts including:**

- 1) Patents
- 2) Industrial designs relates to features of any shape, configuration, surface pattern, composition of lines and colours applied to an article whether 2-D, e.g., textile, or 3-D, e.g., toothbrush.
- 3) Trademarks relate to any mark, name, or logo under which trade is conducted for any product or service and by which the manufacturer or the service provider is identified. Trademarks can be bought, sold, and licensed. Trademark has no existence apart from the goodwill of the product or service it symbolizes.
- 4) iv Copyright relates to expression of ideas in material form and includes literary, musical, dramatic, artistic, cinematography work, audio tapes, and computer software.
- 5) v Geographical indications are indications, in the territory of a country or a region in that territory where a given quality, reputation, of the goods is essentially attributable to its geographical origin”<sup>8</sup>.

IP law provides four areas for building general structure to the IP rights, that structure WIPO problem with cultural and mental aspect. Now we are thinking about changes in new human resources. Patents can be granted for products and processes or contract connected with the human resource.

“As per the Indian Patent Act 1970, the term of a patent was 14 years from the date of filing except for processes for preparing drugs and food items for which the term was 7 years from the date of the filing or 5 years from the date of the patent, whichever is earlier. No product patents were granted for drugs and food items. India is a signatory to the Berne Convention and has a very good copyright legislation comparable to that of any country. However, the copyright will not be automatically available in countries that are not the members of the Berne Convention”<sup>9</sup>. For Indian government signature conversion in IP right have huge meaning because now Indian company can be competitive in global market.

### **5. Role of Undisclosed Information in Intellectual Property**

“Protection of secret information is the most important form of protection for industries, other agencies dealing with IPR. Undisclosed information includes formula, pattern, compilation, programme, device, method, technique, or process. At every development stage people have evolved methods to keep important information secret, mainly by limiting the knowledge to their family members. Laws relating forms of IPR are at different stages of implementation in India, but there is no separate and exclusive law for protecting undisclosed information/trade

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<sup>8</sup> <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3217699/> 6/6/2018

<sup>9</sup> <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3217699/> 6/6/2018

secret or confidential information”<sup>10</sup>. The above paragraph discuss about importance of undisclosed information in intellectual property. Globalization has resulted into large investment in R&D. This process is characterized by high risk of reverse engineering by competitors. Industries came to realize that trade secrets were not adequate to guard a technology.

## 6. The Role of Patent Cooperation Treaty

“All activities related to PCT are coordinated by the world intellectual property organization (WIPO) situated in Geneva. In order to protect invention, it is essential to file an independent patent application in country of interest; in some cases, to obtain priority in these countries. This would entail a large investment, within a short time, to meet costs towards filing fees. In addition, due to the short time available for making the decision on whether to file a patent application or not, may not be well founded. Inventors of contracting states of PCT can simultaneously obtain priority for their inventions without file separate application in the countries of interest; thus, saving the initial investments towards filing fees. In addition, the system provides much longer time for filing patent application in the member countries”<sup>11</sup>. The above paragraph explains role of patent cooperation treaty in protecting invention of an independent patent application in country of interest.

## 7. Innovation

Definition innovation: Innovation understand as industry 4.0 is harnessing and enhancing leadership along with innovation talent.

### 7.1. Definition industry 4.0

The autonomous networking of machines and systems along with the inclusion of big data analytics could help to predict maintenance issues or system failures and react to them accordingly.<sup>12</sup> Just like steam power, and digital automation of the past, cyber-physical systems will create the smart factory. Originating from Germany as part of a Governmental strategy for the computerization of factories, this is a revolution that will spread across industries globally. Cyber-physical systems provide factories with increased connectivity between management level and the production floor. They’re able to monitor the manufacturing process in real time and make decentralized decisions based on

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<sup>10</sup> <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3217699/> 6/6/2018

<sup>11</sup> <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3217699/> 6/06/2018

<sup>12</sup> Oueslati, W., Akaichi, J., 2010. A Survey on Data Warehouse Evolution, International Journal of Database Management, Vol. 2(4), pp. 11-24.

data feedback through these networked machines. Saving valuable time and money for companies.

## 8. Best practices

Intellectual Property must be understood in all part of the business. Example of the practical guidelines for business are:

- 1) “understand and support the value of IP as the basis of innovative, creative and economic activity that promotes;
- 2) business and national competitiveness;
- 3) manage their own copyrights and trademarks more effectively;
- 4) comply with the IP laws protecting other companies’ copyrights and trademarks;
- 5) manage the business risks associated with infringement;
- 6) prevent and deter counterfeiting and piracy; and
- 7) develop company policies and practices to effect such compliance”<sup>13</sup>. IP guidelines to provide information to business on practical steps to take to protect creativity in working process and business. In other aspects many businesses have variety of IP issues with which a company must deal are growing.

### 8.1. *The best practice for start-up:*

- 1) Maximize resources:

In this day and age, obtaining information isn’t the challenge – it’s sifting through the endless streams of data, insights and email exchanges that soak up more time than the analyses themselves. There are myriad online tools available for entrepreneurs. Building a better business with outsourcing tools is a great way to keep the grind wheel turning when your energy reserves are low.

- 2) Leverage your network:

There are five types of people in network: family, friends, uppers, downers and influencers. Family and friends speak for themselves, and may also serve as mentors or role models. Uppers term is applicable for people, who are not strategists and they do not execute well but they love life and have fun sitting in the dark. Their evil twins, however, are downers, who are the human toxins that act as social hand grenades because of their negativity<sup>14</sup>.

- 3) Build a learning culture:

Culture is a product of the people, processes and systems that define the company’s name and all that it stands for. You don’t change a culture without

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<sup>13</sup> [https://www.uscib.org/docs/BASCAP\\_IP\\_Guidelines.pdf](https://www.uscib.org/docs/BASCAP_IP_Guidelines.pdf) pages 5 6/6/2018 r.

<sup>14</sup> <https://www.entrepreneur.com/article/239348> 6/06/2018

changing behavior, and you only change behavior at scale through the systems and processes that guide the company's daily execution.

4) Have an MVP:

A minimum viable product is achieving two objectives: maximizing value to the customer and minimizing costs by introduction the least amount of product or service to market good judgment only comes from experience, and experience typically comes from bad judgment.

## ***8.2. General legal background and problems of ownership rights***

### ***The rights concerned***

The IPRs can be divided into formal rights acquired by registration and informal rights not necessitating registration. The distinction is important in relation to rights management, as will be explained later. Other rights such as trademarks may be involved, but for present purposes we are not concerned with these.

### ***Ownership***

The ownership of IPRs is at present a matter for national law, and national laws differ. International conventions have standardised the basic IPR system since the late nineteenth century. However, these conventions in themselves are ineffective as enforcement mechanisms because they do not impose sanctions for non-compliance. Moreover, the problems and disputes of ownership in connection with IPRs at present must deal with individual national laws, and in many cases disputes about these matters are determined before authorities not specialised in dealing with IP matters, such as labour courts. This is also true for countries on the verge of accession to the European Union and countries outside Europe. Moreover, even within Europe, and in accession countries, only some aspects of the national laws have been harmonised<sup>15</sup>.

### ***Enforcement***

Within the EEA, the Brussels and Lugano Conventions on jurisdiction and the enforcement of judgements are in operation, but have deficiencies in relation to IPRs. Improved and harmonised (cross-border) enforcement is under discussion by the Hague Conference on Private International Law, but it remains to be seen what intellectual property proposals, if any, it will produce. The possibility of a pan-European court system, at least for patent disputes, is being considered, and we believe this development is to be encouraged and ideally should have

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<sup>15</sup> Bénédicte Callan, Giovanni F. Casucci, WORKING PAPER Expert Group Report on Role and Strategic Use of IPR (Intellectual Property Rights) in International Research Collaborations Final Report – April 2002.

jurisdiction over all forms of IP dispute, given that the functions of the different types of property often overlap<sup>16</sup>. The objective of this court or courts would be to provide appropriate and speedy decisions at reasonable cost.

## 9. Background and foreground knowledge

“Collaborative ventures involve background knowledge: existing IPRs, trade secrets and other confidential information, as well as other valuable knowledge which the parties bring to the project and which, whilst not qualifying for legal protection, is nevertheless valuable to the project. The object of contractual provisions relating to background knowledge is to ensure:

- 1) Disclosure of all such knowledge by the collaborators as is necessary for the project, if not at the outset, at least as soon as its importance becomes apparent;
- 2) The other collaborating parties can use this knowledge without infringing IPRs.

Confidentiality on the part of all the collaborators in respect of such knowledge as may be disclosed to them by the other contributors. In general, use of such knowledge will be limited to the attainment of the objectives of the programme. Subsequent use for exploiting research outputs will usually require a further licence. A provision will usually be inserted entitling participants to such a licence on ‘fair and reasonable terms’. Foreground knowledge is IPRs, including trade secrets and other confidential information, as well as other valuable knowledge, which are produced by the collaboration. Reflects the ideas IP rights that this owner -subject and know how are matter, now we understand them as the “product of the mind” (intellect) and that may be protected by law in the same form as any other property (documentation company)”<sup>17</sup>. The above mentioned paragraph explains about background knowledge: existing IPRs, trade secrets and other confidential information. Foreground knowledge is IPRs, including trade secrets and other confidential information, as well as other valuable knowledge, which are produced by the collaboration.

## 10. Conclusion

Business intelligence technology can obtain high quality and guidance information to help enterprises analyse problems, do timely and accurate decision-making to enhance the level of logistics services, improve internal operation efficiency and competitive advantage.

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<sup>16</sup> WORKING PAPER Expert Group Report on Role and Strategic Use of IPR (Intellectual Property Rights) in International Research Collaborations Final Report – April 2002.

<sup>17</sup> [http://ec.europa.eu/research/era/pdf/ipr-eur-20230\\_en.pdf](http://ec.europa.eu/research/era/pdf/ipr-eur-20230_en.pdf) 6/06/2018

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