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Identifying Factors Associated with Food Losses during Transportation: Potentials for Social Purposes

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Abstract: The problem of food waste and food loss covers the entire food chain, and its scale varies depending on the part of the chain. The aim of the study was to identify a problem and indicate places where goods redistribution is possible at the food transportation stage. The article provides a detailed breakdown of the causes of losses at the transportation stage. The research material was a large dairy cooperative in Poland. It was found that it was possible to recover 25.08 tons of dairy products. Taking into account the total weight of the cargo carried by all transport units during the analyzed period, this amount is approximately 0.5% of the full load capacity of all transport units in a two-year period. The research conducted shows that losses during the transportation of finished goods are generated, therefore it is possible to recover part of the food during the loading, transportation and unloading stages. The present practice involves an unconditional disposal of all products, which for various reasons are not delivered to the customer at the appropriate time and in proper commercial quality (accidents, collisions). The disposal of ready, often packed, completely safe products is a highly undesirable phenomenon, especially in the context of the poverty experienced by part of society.

Keywords: food loss; food waste; dairy products; transport

1. Introduction

Numerous institutions operating in various areas of social life (Food and Agriculture Organization—FAO, European Union—EU, European Food Banks Federation—FEBA) undertake a wide range of activities aimed at raising awareness of the scale of food waste and thus the possibility of limiting or minimizing this undesirable phenomenon. Currently, a delegated decision is being prepared by the European Commission. This document will require all European Union member states to submit reports on losses at particular stages of the food chain, including at the stage of transporting the finished products [1]. FAO data show that as much as 1.3 billion tons of edible food is wasted worldwide each year, which makes up 1/3 of global production [2]. In 2012, the residents of 28 European Union countries were responsible for the waste of approximately 88 million tons [3]. In this shameful ranking, Poland is ranked fifth (about nine million tons of food annually). The greatest responsibility for the waste of food articles in the European Union is borne by citizens and companies in the United Kingdom, Germany, the Netherlands and France [4].

The scale of waste varies, depending on the element of the food chain. According to the report Preparatory study on food waste across EU27 [4], the majority of food waste is generated in households (42%), followed by distribution (39%), the food service sector (14%) and retail and wholesale sales (5%).

Inadequate storage conditions are the main cause of the loss of food products at the stage of production and distribution. The shelf life of many products depends on the optimal temperature

and transportation conditions. Cold chain ruptures can have a dramatic effect on food quality and losses [5]. At this stage of the food chain, an important role is also played by the type and strength of the packaging material to be used (susceptibility to mechanical damage during storage and transportation), logistics for production and distribution [4].

Overproduction and the overestimation of procurement resulting from incorrect tracking of market demand mechanisms are an important problem [6]. These issues are particularly important in the case of seasonal production and consumption of different product groups, and during peak sales periods (holidays, long weekends, etc.). Jedermann et al. [5] indicate that problems arising from long transport distances will require increased attention in the future, owing to the globalization of the food supply chain with distant production locations, especially during the consuming country's winter season, as production comes from locations in the opposite hemisphere.

European Union documents call for a reduction of food waste on all stages of the food supply chain. These activities are related to the "Europa 2020 Strategy", and therefore many countries are looking for new solutions to reduce the scale of food waste [4]. In Poland, no comprehensive research on the quantity and causes of food waste has been conducted to date. An innovative initiative aimed at estimating and identifying a solution to this problem is the project "A model for reducing the losses and waste of food for the benefit of society" (acronym MOST) [7]. One of the elements of the project is the analysis of losses at the stage of transportation at an exemplary food manufacturing company. The project partner representing the food industry is a leading dairy cooperative in Poland, and therefore the study covered milk and dairy products [8].

The reason why the research investigated the transportation stage is because in the literature there are no results confirming the creation of food losses and food waste during the transport of goods. The available literature presents data that relates to the distribution of food products. Salihoglu et al. [9] indicate that in Turkey alone, 2.25 million tons of food is wasted per year at the distribution stage. At the same time, distribution is a quite broad term and includes many additional activities which are not directly associated with the movement of goods (for example, storage in distribution centers). Gustavsson [10] emphasizes that milk losses in distribution in middle-and high-income countries (including Europe, Russia, and the USA), including sales, equal 0.5%. While Raak et al. [11] identifies significant causes for food waste in the supply chain related to logistical handling, product processing, and consumption.

Literature data indicate that food losses at the stage of transporting finished goods in Poland may be as high as 30% [12]. That amount consists of finished goods which are safe and edible for consumers. Meanwhile, under the insurance policy, all goods withdrawn at this stage are recycled. This fact led the authors to initiate research on food losses at the transport stage.

In many publications [3,13,14] the scale of the food waste problem is presented. There are a lot of possibilities of a decrease in the scale of that problem and one of them is redistribution for social purposes [15–17]. However, only rarely are solutions presented for the possibility of redistribution of this food. The novelty of this study is that the proposal of a method shows the possibility of establishing food redistribution points during the transport stage. Designated food redistribution points provide the opportunity to redirect for social purposes products that are safe for consumers.

The first theoretical aim of the study was to identify the causes of losses at the transport stage and to carry out a risk analysis to indicate the points from which it would be possible to transfer food products for social purposes (RP-redistribution point). The second aim was verification and confirmation of designated RP on the basis of a survey conducted among entities providing product transportation services for a dairy cooperative in Poland.

2. Material and Methods

The method for the theoretical part (determining the causes of losses and risk analysis) was the Ishikawa diagram developed by MOST (a model for reducing the losses and waste of food for the benefit of society) specialists indicating the causes of food losses across the whole food chain [18].

The diagram, also known as a fishbone diagram, is used to illustrate cause-and-effect relationships, which facilitates the separation of causes from the effects of a given problem and to discern its complexity [19]. At this stage, the environment is quite important, so it was decided to use the Ishikawa 5M + E diagram model (5M + E: Man, Management, Machines, Materials, Methods + Environment) which consists of the determinants man/people, environment, management, methods, machinery, and materials. On this basis, potential RPs were determined using risk analysis. Based on the literature and consultation with transportation specialists and quality assurance specialists, the general diagram was adapted to the needs of product transportation by using the "brainstorming" method. Transportation and quality assurance specialists who provided information and participated in the brainstorming process were long-term employees of the dairy cooperative where the research was carried out. They were competent professionals and fully versed in the discussed issues. Additionally, during the discussion, it was possible to verify the data by viewing related documentation. Expert opinions were crucial in brainstorming, which according to Antoszkiewicz [20] is based on a free exchange of views in a team selected by the criterion of knowledge of the subject.

The identification of food redistribution points (RPs) was developed in accordance with the principles and assumptions of the mandatory HACCP system, risk analysis and risk reduction for dairy product quality. This analysis was constructed by MOST specialists for the whole food chain [18] and was then adapted to goods transport (Table 1). Food redistribution is possible only if the product is safe for the consumer. The Codex Alimentarius [21] defines food safety as ensuring that food does not harm the consumer's health if prepared and/or consumed according to the intended use.

Table 1. Risk analysis table.

Stage of Transportation	Category *	Factor (*Type of Exposure*)	Cause	Effect	Significance of Hazard **/RP ***
Loading/ transportation/ unloading	S/NV/SV/A	What event had an impact on the goods exclusion from the market (*mechanical*, *environmental*, *chemical*, *biological*)	On the basis of the Ishikawa diagram	Type of damage—indication of recoverable products	1, 2, 3/YES, NO

* Category: S—safety; NV—Low Nutritional Value; SV—Low Sensory Value; A—Low availability (i.e., damaged package). ** Significance of hazard: 1—Food redistribution is possible/include damaged package without interruption of its continuity, dents, incorrect label; 2—Food redistribution is possible/It is necessary to segregate the products to separate them from the entire pool of valuable products. Damage that does not affect the health of food articles involve primarily the deterioration in the quality of the products; 3—Food redistribution is impossible. *** For all designated RPs, critical limits will be determined. Source: [18].

A redistribution point is defined as an operation or step in the food chain "from the field to the table", in which action can be taken to prevent or eliminate the risk of wasting the food product, with the possibility of transferring to social purposes. Risk analysis is defined as the process of collecting and assessing information about the possibility of threats that could potentially lead to the inability to use the product for consumption. The condition necessary to classify a factor as an RP was product safety. Thus, breaking the protective barrier of the pre-package, or breaking the chain, disqualified the product and thus excluded its delivery for social purposes.

To verify the identified points, surveys were carried out among transportation companies. The survey questionnaire consisted of a metric and 18 questions (single and multiple-choice questions and open questions) related to issues such as driver responsibilities, reasons for not accepting goods by the recipient, the weight of unopened articles, specific features of mechanical damage during transportation, operations with mechanically damaged articles (Appendix A). The Ishikawa diagram was used to construct the survey.

The material for the practical part (verification and confirmation of RPs) was provided by 46 companies transporting ready-to-eat products, which provide services for a dairy cooperative in Poland. This plant produces a full range of dairy products, offering over 500 different products sold throughout Poland. All companies engaged in dairy products transportation services were external

entities cooperating under an appropriate agreement concluded with the given dairy cooperative. In addition, each company provided services by more than one transport unit (a vehicle designed for transporting food products). More than half of the companies had worked with the production plant for more than 10 years. The detailed characteristics of the 46 analyzed transportation companies are presented in Table 2. The survey involved the transportation of ready-to-eat products during 2013 and 2014. Forty-six questionnaires were distributed and received (23 for each year).

Table 2. Characteristics of the 46 transport companies involved in the questionnaire survey (per two years).

Number of Transport Units		Load Capacity of Transport Units		Number of Trips Per Month	
Total	**Average ***	**Total ****	**Average ***	**Total**	**Average ***
204 pcs.	4.7 pcs.	4859.5 tons	107.85 tons	1.617	35.15

* Per one carrier ** per 46 carriers Source: author's own research.

3. Results and Discussion

3.1. Identification of the Causes of Loss and Waste of Food at the Stage of Transportation

The efficiency of the goods transport process is conditioned by many factors. These include selection of the appropriate type of transport packaging, type and condition of the transport, location and protection of the goods in the cargo space, the availability of handling equipment and its condition, storage space infrastructure (e.g., the presence or absence of a ramp or slipways on the routes), as well as adapting the tactics of driving to the type of transported goods [22]. The lack of the necessary attention or commitment may result in a reduction of the quality of transported goods or a delay in delivery.

An Ishikawa diagram was developed. This made it possible to identify potential causes of dairy product losses during the transportation operations. For each of these categories, a detailed analysis was performed.

One of the causes of losses during transportation is the human factor, i.e., man/people (Figure 1). As was stated by Bilska et al. [18], the appropriate qualifications and high level of knowledge of the employees make them capable of making difficult decisions, which may include decisions aimed at the improvement of work efficiency, and consequently reduce the level of losses. An essential element in the process of reducing the risk of errors is also compliance with applicable work procedures and continuous improvement.

The second identified category of the causes of food loss and waste at the stage of transportation is the environment (Figure 1). Transportation (including the time of delivery) of food articles must be carried out so as not to reduce its durability. The factors determining the growth rate of microorganisms responsible for the spoilage of transported food articles, and thus their durability include temperature and ambient humidity [23]. Milk and most milk products require a continuous refrigeration chain from production to consumption. Therefore, the carrier is obliged to maintain a suitably low temperature during transportation. The requirements concerning the transportation of food articles such as milk are referred to in Section IX, Chapter I of Regulation (EC) 853/2004, dated 29 April 2004, stating the specific hygiene rules for food of animal origin [24]. To maintain the required low temperature of the transported dairy products, the processes of loading and unloading to/from the means of transportation should be carried out very efficiently. The maintenance of appropriate conditions during transshipment operations during the hot season is particularly important. At that point, prolonged loading/unloading leads to an undesired increase in the temperature in the cargo area. Environmental conditions are not so significant when the ambient temperature is low and transient long-term handling processes do not have a significant effect on the temperature inside the means of transportation. The necessity of transporting food over greater distances increases the number

of intermediaries. As a consequence, losses can occur if the open-door time is exceeded during the unloading of the product [25].

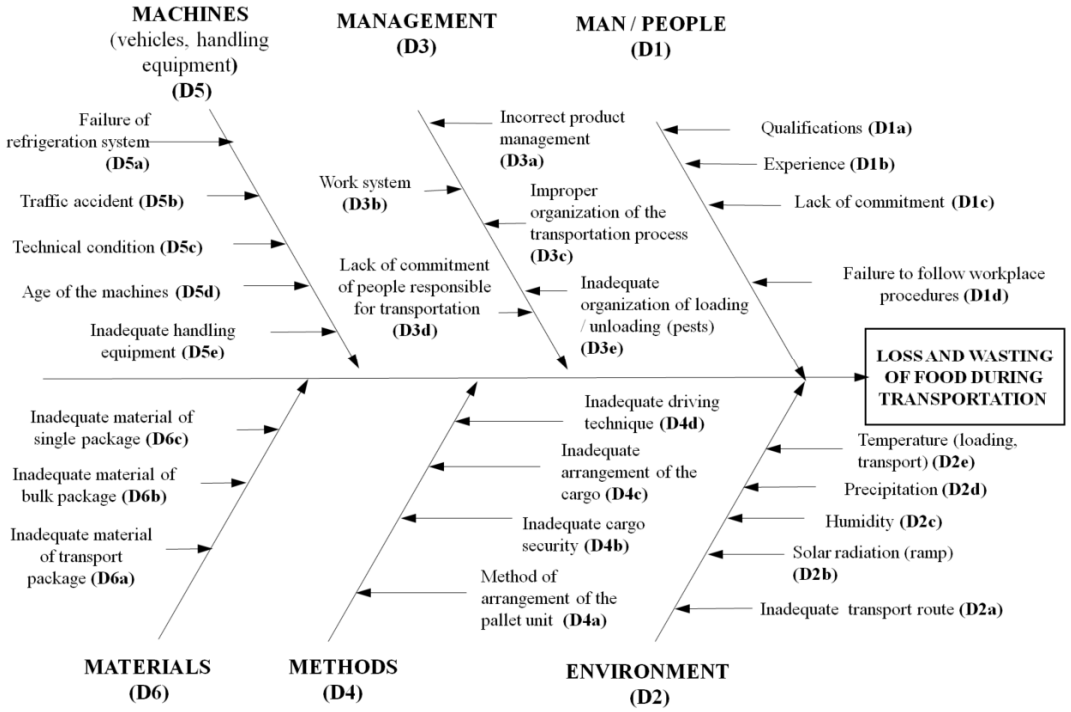

Figure 1. Causes of losses of dairy products at the stage of transportation. Source: author's own elaboration based on [18].

Another important category, potentially determining the loss of food at the transportation stage, is management, i.e., the inadequate work management processes involving both loading and unloading personnel and managers responsible for the organization of transportation (Figure 1) [18]. The quality of their work depends on the training carried out by appropriate institutions. To minimize the losses at the stage of transportation, it is important to organize the processes of loading, circulation of the means of transportation and unloading of the transported cargo. It is important to adjust the route accordingly, as the improper placement of goods together with high vibration during transportation causes mechanical damage of the packages. Today, the distance between primary production plants and food consumption areas is increasing, resulting in the necessity of transporting food products over greater distances, maintaining the refrigerated chain for a longer period of time (for products of animal, plant and frozen origin) [25]. A transportation period that is too long, that is, improper logistics, results in the product reaching the consumer with a shorter shelf life. This element is particularly important for perishable products. Meanwhile, consumers buying food products are increasingly paying close attention to the information on the label [26]. Nearly 40% of people indicated that they read the information on the label in the grocery store [27]. As shown by Bandara et al. [28], the information most frequently sought on the label of a product is the expiry date (80% of respondents) and the nutritional value of the product (74%).

Another important criterion of the adapted Ishikawa diagram are the methods (Figure 1). According to Hammond et al. [29], the processes of transportation and storage of food are closely interrelated. Transporting food over long distances requires the prevention of spoiling during the transportation, so progress in transportation technology plays a very important role in this regard. Due to the spatial heterogeneity (route types) it is necessary to arrange and safeguard the food articles and to avoid mistakes made during transportation of the cargo, e.g., mismatch of speed and driving dynamics. Goods should be evenly stacked on the pallet and additionally protected from spreading by wrapping with stretch film. In addition, the pallets should be positioned in the cargo area to prevent

slipping during transportation. Inadequate driving dynamics and the lack of precautions result in damage that may be caused by displacement of the cargo or an accident.

The level of losses and wastage of food products during the transportation stage may be caused by inadequate materials used to secure the finished product (single packages) or the cargo (bulk and/or transport packages) (Figure 1). When selecting the packaging materials, such aspects as their hardness, brittleness, elasticity, durability, gas or water impermeability are important, because they are barriers to damage [30]. The last category of the Ishikawa diagram are machines (Figure 1). The poor technical condition of the machinery (cars, handling equipment), which is often caused by age and poor or overdue maintenance and rare inspection processes, leads to numerous accidents, which can directly translate into the amount of lost food. For the transport of food, which requires specific conditions of the carriage, regular vehicle and cooling system inspections should be carried out [18]. In the case of isothermal trailers in which dairy products are transported, after some period of time leakage may occur, which has a significant impact on maintaining the right temperature and quality of the transported products. According to applicable legislation, the temperature of the food articles transported at each measuring point cannot exceed the temperature recommended for the given commodity group (including the temperature during loading and unloading) [31].

3.2. Analysis of Hazards and Risks of Dairy Product Quality Deterioration during Transportation

Taking the Ishikawa diagram into account, an analysis of the risk of deterioration was carried out, as well as the test of health security of milk and its products during transportation. On that basis, redistribution points (RPs) were identified. Critical limits were also defined for all designated RPs (Table 3). Based on the hazard analysis, redistribution points were identified for the loading, transportation and unloading stage. It was shown that only under low availability, i.e., a damaged package without interruption of its continuity (A) is it possible to recover food at the stage of goods transport. More than half of the designated points refer to events, in which the transport package (pallet unit) is deformed, absorbing package or single package damage, carton dents/deformations, cups, PET bottles without breakage of the safety barrier (uniformity). The remaining refer to the situation, in which the contents of a defective single package of the product (continuation of a single package as a part of a pallet) contaminate the contents of the whole pallet. All of the above events do not cause health-safety degradation, but adversely affect commercial quality (products are not attractive to the customer).

3.3. Verification Identified RP on the Basis of a Survey

The possibility for redistribution of articles damaged during transportation is conditioned by the type of factor involved. The most important arising during transportation are mechanical, environmental and biological factors. Analysis of the obtained survey results confirmed that there was a possibility of food redistribution from the availability category (A), i.e., damaged package without interruption of its continuity (Table 3). Respondents indicated that the most common cause of non-receipt of the delivered goods was the mechanical factor (mechanical damage) (Table 4). Along the whole, the food supply chain bears the risk for mechanical product damages. These damages may have different consequences, starting with a simple package deformation that leads to rejection by the recipient or to a decreased attractive-ness to consumers [32]. Palka [12] showed that the most frequent transport damage found in Polish companies was mechanical damage. It was the most common indicated threat and occurred in nearly 75% of respondents. The author highlighted that inadequate temperature conditions during transport or physical contamination of transported products (sand or glass), were less common.

Table 3. Analysis of hazards and risk of dairy product quality reduction during the transportation stage of dairy products.

Stage of Transportation	Category	Factor (*Type of Exposure*)	Cause (on the Basis of Ishikawa Diagram)	Effect	Significance of Hazard/RP *
Loading/unloading from the means of transportation	A	Deformation of transport package (pallet unit) or bulk container due to improper arrangement placement of goods and/or security of transportation package (*mechanical*)	D1a, D1b, D1c, D1d, D3b, D3e, D4a	Goods unattractive for trade but still valuable	1/YES
Loading/unloading from the means of transportation	A	Damage of a single package, dented/deformed cardboard, cup, PET bottles without breaking the protective barrier (*mechanical*)	D1a, D1b, D1c, D1d, D3b, D3e, D4a	Goods unattractive for trade but still valuable	1/YES
Loading/unloading to/from the means of transportation	A	Contamination of the contents of the pallet with the contents of the damaged single package (breaking of the continuity of the single package, which is part of the pallet) contained in the transportation package (*mechanical*)	D1a, D1b, D1c, D1d, D3b, D3e, D4a	The product is unattractive for trade but valuable after carrying out proper cleaning/washing procedures Exception is a single package with broken protective barrier	1/YES
Loading/unloading to/from the means of transportation	S	The damage of a single package (cardboard, foil bag, mug, bar, aluminum foil, PET bottle) causing the breakage of the protective barrier (*mechanical*)	D1a, D1b, D1c, D1d, D3b, D3e, D4a, D6a, D6b, D6c	Breakage the protective barrier of a single package, the goods are dangerous for the consumer, Possible risks of biological, physical and chemical nature	3/NO
Loading/unloading to/from the means of transportation	S SV	Failure to meet loading/unloading conditions (incorrect temperature and operating time) (*environmental*)	D1d, D2b, D2c, D2d, D2e, D3a, D3b, D3d	Dangerous product-proliferation of pathogenic microorganisms, Change of sensory properties	3/NO
Transportation the cargo by means of transportation	A	Damage of transportation package (pallet unit) of the following type: Shifting of bulk packages in the vertical plane of the pallet due to improper protection of the transport package Dented deformation of carton, cup, PET bottles due to improper arrangement of goods and/or security of transport packages during transportation (*mechanical*)	D1a, D1b, D1c, D1d, D4d, D5b, D5c, D5d, D5e	Goods unattractive for trade but valuable	1/YES
Transportation the cargo by means of transportation	A	Contamination of the contents of the pallet with the contents of the damaged single package (breakage of the continuity of the single package, which is part of the pallet), as a part of transport package (*mechanical*)	D1a, D1b, D1c, D1d, D4d, D5b, D5c, D5d, D5e	The product is unattractive for trade, but valuable after carrying out proper cleaning/washing procedures Exception is a single package with broken protective barrier	1/YES
Transportation the cargo by means of transportation	S	Damage of a single package (cardboard, foil bag, mug, bar, aluminum foil, PET bottle) causing the breakage of the protective barrier (*mechanical*)	D1a, D1b, D1c, D1d, D4d, D5b, D5c, D5d, D5e	Breaking the protective barrier of a single package, dangerous for the consumer, Possible risks of biological, physical and chemical nature	3/NO
Transportation the cargo by means of transportation	S SV	Nonobservance of the correct environment/environment, improper organization of work) (*environmental*)	D2a, D3c, D3d, D5b, D5c, D5d	Dangerous product-proliferation of pathogenic microorganisms, Change of sensory value	3/NO

* For all designated RPs, critical limits were defined: Continuity of a single package, shelf-life, making it possible to deliver goods to people in need (three working days); weight (partner organization: Min. 50 kg, receipt by FB: Min. 100 kg). Source: author's own research.

Table 4. Exposure caused by non-acceptance of goods by the recipient by number of indications (data for 2013–2014).

Type of Exposure	Number of Cases in the Analyzed Period	Estimated Monthly Number of Cases
Mechanical	46 (17 carriers)	2
Environmental	2 (1 carrier)	0.08
Chemical	0	0
Biological	0	0
Others (*short terms*)	7 (2 carriers)	0.3

Source: author's own research.

Another factor which was not identified on the basis of hazard analysis but was demonstrated during the survey was a short time to the date of expiry (15% of the indications). Currently, more and more food labeling systems are being developed around the world, which provide information on the number of days the consumer has to consume a given product, counting from the date of production. This is aimed to meet the needs of the demanding customer, who wants to have access to basic information when choosing the product, not only in the shop [33]. On the basis of the obtained results, it was found that 4% of respondents indicated that they did not accept the environmental exposure that can damage or destroy the transported goods. In the case of transportation of food articles, especially those requiring continuity of the refrigerant chain, the most common type of climatic exposure is failure to meet the temperature requirement. The level of loss of finished articles at the transportation stage in the analyzed dairy cooperative over a two-year period was low and acceptable in the total production scale. However, it should be emphasized that amounts that are insignificant for the plant itself may be very important for people, who find themselves in a difficult financial situation. The same solution was presented by Bilska et al. [34] and based on data demonstrated that two weeks of acceptable losses of milk and milk product in one supermarket could feed 104 women or 82 men aged 31 to 50.

The mechanical factor resulted in the exclusion of 24,980 kg of products from the trade turnover in a two-year period and 750 kg as a result of environmental exposure (Figure 2). As a result of these events, the package was damaged, so as to disrupt the protective function which preserves the product from adverse weather conditions, or crushes of the packaged product and other undesirable factors. The customers making purchases are also guided by the design and condition of the packaging, so damage will have a negative impact on their purchase decisions. The studies show that even subtle packaging features such as color or shape are important for the choice of food articles [35]. The respondents indicated that in the event of a significant damage to the transport package ("scattering" of the pallet or deformation of the package), the item is returned to the production plant or products are disposed of. According to the requirements of the transport department, all transportation units had insurance of cargo, so-called OCP (carrier's civil liability), which involves the reimbursement of costs incurred as a result of damage incurred during transportation. In Poland today, compensation is regulated on the basis of documents confirming the disposal of damaged goods, withdrawn from commercial turnover.

The second type of mechanical damage was a break in the continuity of a single package, which resulted in the contamination of the remaining packages in the bulk package. Similarly, respondents indicated that they would return such a package to the production plant or dispose of it.

Another factor, according to the number of indications, why the goods were excluded from further commercial turnover was a short shelf life (15%), which was related to improper product management. Mechanical damage (without breaking the protective barrier of the package) and a short shelf life do not directly affect a reduction of health safety. Based on the research (Figure 2), it was found that it was possible to recover parts of 25.08 tons of products (24,980 kg categorized as mechanical damage and 100 kg categorized as short terms). Taking into account the total weight of the cargo carried by all

transportation units during the analyzed period, this is approximately 0.5% of the full load capacity of transport units in a two-year period. That value corresponds to the weight, which is slightly higher than the average capacity of the transportation unit (23 tons). Thus, it can be estimated that during the analyzed period (two years), the cargo was transported in one course for disposal. A beneficial, but so far rarely practiced option in this area, would be the use of logistics redistribution, i.e., the flow of products from widespread transport units to entities, which deal with food management [6].

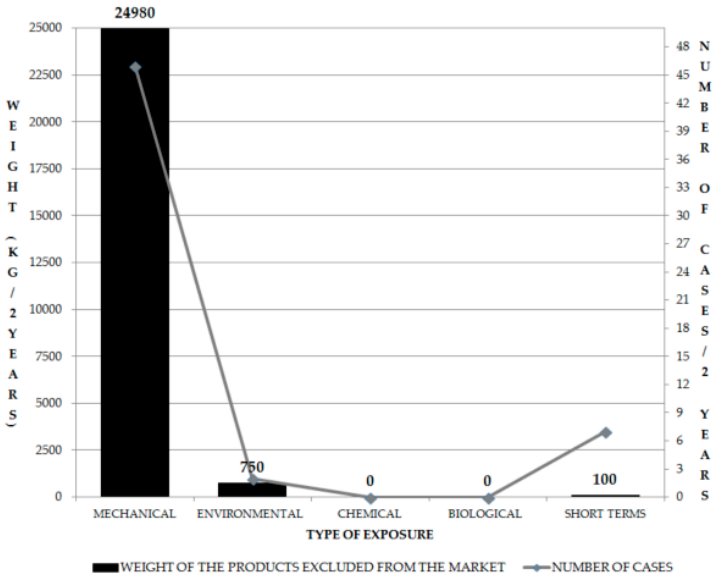

Figure 2. The weight of the products (kg) excluded from the market at the stage of transportation, depending on the type of exposure (data for 2013–2014). Source: author's own research.

The smallest number of indications, among the types of exposures that result in the exclusion of goods from commercial turnover, is inadequate environmental conditions (Figure 2). However, in this case, due to the likelihood of food safety hazards, these products were not classified as able to be transferred for social purposes.

The results obtained in our own research indicate that the transportation control process starts the moment the goods are loaded. Every time before loading, the carrier's documentation (such as certificates, a veterinary certificate for the transport of foodstuff, the driver's medical record book), cargo area cleanliness and aggregate efficiency are checked before loading. The carrier is obliged to maintain constant temperature during transportation and the efficiency of the equipment is checked by generating a temperature print of the thermograph (measurement frequency every 15–30 min). All respondents indicated the right temperature range needed to maintain dairy products during transportation, 87% of respondents indicated that the recipient checks the temperature during the procedure of acceptance of finished products. Seven transport companies indicated that there were cases of breakage of the refrigeration chain during transportation; the total number of cases per year was 167. The main reasons include the factors analyzed in the Ishikawa diagram (Figure 1), i.e., cooler failure and opening the door with too high a frequency and for too long. Currently, when transporting food products, electronic recorders are most commonly used for temperature measurement. In addition, the temperature of the means of transportation is checked each time the goods are loaded [31]. If the recipient finds an abnormality/temperature deviation from the recommended range, then the goods are not accepted. If the carrier fails to meet the right conditions during transportation (deliberate shutdown of the unit for a short period of time to reduce costs), then the carrier has to bear the costs of disposal. There were no events that disqualified goods related to biological or chemical factors during the analyzed period.

Another important factor, in terms of the potential for food redistribution for social purposes, is the number of accidents/collisions involving transport units carrying goods. The dairy cooperative pointed out that in case of accidents, collisions or other incidents, which make it impossible to continue the route, and which cause multiple products to show failures that do not affect consumer safety, all goods are subject to recall. The transport specialist in the analyzed company noted three road collisions in 2014. Information from 2013 is not available. Taking into account the annual number of courses of all transportation units, only 0.03% of them were involved in a collision and the goods carried by them (approx. 60,120 L of milk) were recycled.

Estimates by the Institute of Agricultural Economics and Food Economy indicate that the average consumption of milk and dairy products in 2016 may be as high as 207 L per capita in Poland [36]. Consequently, the amount of waste disposed of as a result of collisions and product accidents corresponds to the annual consumption of milk by 290 people.

3.4. Confirmation Identified RP on the Basis of a Survey

The last part of the research involved the confirmation of the RP by analyzing the results obtained.

Mechanical damage, which did not result in discontinuity of the single package but caused non-acceptance of the cargo by the customer, included the tilt in the vertical plane of the pallet unit (1500 kg), the deformation of single or bulk packaging (1,012 kg) (Table 5). There were also situations, in which the single package protective barrier was broken and other products were contaminated by the spilled product in the collective/transportation package (1,507 kg). In addition, half of the respondents declared that the contamination of one pallet, which is a part of a pallet unit due to discontinuity of the single package (the remaining pallets are clean) results in the non-acceptance of the entire pallet unit (transportation package) by the recipient. One of the respondents pointed out a case of mechanical damage, which involved a significant weight (21,600.5 kg), but no detailed description of the type of damage was indicated. Analysis of previous cases allows one to conclude that some of these products were still fit for consumption, so the redistribution of large quantities of products would be possible.

Table 5. The type of mechanical damage, which caused the non-acceptance of the cargo by the recipient over two years.

Type of Mechanical Damage	Share %	Weight of the Damaged Goods [kg/2 Years]	Average Monthly Value [kg]
No description	22	21,600.5	900
Deformation of a single or bulk package	31	1012	42.2
Tilting of transport package (pallet unit)	9.5	1500	62.5
Breaking up of package, bulk or transport	37.5	1507	62.8

Source: author's own research.

The author's own research (Table 6) shows that the most common losses occur at the stage of shipment by means of transportation (19 indications). Next, was the stage of unloading the goods from the means of transportation (16 indications) and loading into the means of transportation (12 indications).

Table 6. Confirmation designated RP.

RP	Number of Cases/2 Years	Weight (kg/2 Years)
Loading into the means of transportation	12	115
Transportation	19	12,500
Unloading at the recipient's place	16	12,355

Source: author's own research.

Defined by risk analysis, the RPs were confirmed on the basis of the analysis of the results of the questionnaire survey. At each stage of the transportation of finished goods, there is a possibility of food redistribution. However, the necessary condition is the appropriate inflow of information and close cooperation between the analyzed dairy cooperative and the organization, which carries out the food redistribution for social purposes (e.g., the FPBŻ: Federation of Polish Food Banks). Food Banks declare they will receive any quantity of food, which the manufacturers wish to donate for the needs of the poor. This can be organized by direct receipt by the order of the food transferee, in case of a cargo of more than 100 kg. When a company wishes to give less food (less than 50 kg) the transport is organized by the Food Bank on the same day to nearby entities from several places/locations. This form is called the partnership transport.

According to the analysis, the critical limit indicated in the hazard analysis (Table 3) was reached. Another condition that must be met for food to be delivered is a minimum shelf life. Food Banks declare their willingness to receive food products, whose shelf-life expires within no less than three business days. This time makes it possible to deliver untested goods to people in need. Currently a small number of food manufacturers are willing to donate food for social purposes. The purpose of the MOST project (a model for reducing losses and wasting food for the benefit of society) is, together with the identification of the potential food redistribution places, the dissemination of information on the potential for such product development, thereby limiting the adverse effects of food waste.

4. Conclusions

The conducted research show that losses during transportation of finished goods are generated, therefore it is possible to recover part of the food from the loading, transportation and unloading stages. It was shown that the most important cause of food losses is the mechanical factor, which is closely connected with the human factor identified in the Ishikawa diagram.

An important achievement of the conducted research is the analysis of the hazards and risk of reduction in dairy product quality during the transportation stage of dairy products. The analysis was carried out on the basis of data obtained from employees of the dairy cooperative in the evaluated company. Content-related cooperation with the employees of the company (the brainstorming method) also allowed identification of the causes of losses of dairy products at the stage of transportation. These actions made it possible to designate food redistribution points in the food transport stage. The designated food redistribution points provide the opportunity to devote products that are safe for consumers to social purposes. Especially important is the social aspect, or the "redirection" of food for people in a difficult financial situation. The present practice involves unconditional disposal of all products, which for various reasons have not been delivered to the recipient at the appropriate time and in appropriate commercial quality (accidents, collisions). Often, these products are completely safe for the consumer. Considering the global trend of limiting food waste, such activities are unacceptable. The disposal of ready, often packed, completely safe products is a highly undesirable phenomenon, especially in the context of poverty, which is experienced by part of society. Aside from the ethical aspect of food waste, a real problem is related to economic (e.g., the costs of utilities, materials, manpower that were used in the production process) and environmental (water consumption, CO_2 emissions) considerations.

To implement the usage results of the conducted analysis in a wider practice, it is necessary to change the insurance law in Poland, which at the moment mandates the unconditional disposal of all products that remain undelivered to the recipient (for various reasons), including those of appropriate quality. The practice which was presented (i.e., confirmed by an appropriate disposal document) is a simple and convenient solution for companies involved in the proceedings and helps in obtaining a quick refund from the insurer. However, it is important to take actions to reduce that practice to an acceptable minimum.

An essential element for unlocking the possibility of the redistribution of such products for social purposes is to change the carriers' liability insurance policy and to provide opportunities for

cooperation between the production plants involved in obtaining food for the people who need it. In addition, employee training, investments in logistics (route optimization, taking into account the condition of roads) can favorably reduce the scale of food losses and food waste at the transport stage.

The "MOST" project currently implemented in Poland can directly contribute to increasing the scale of the redistribution of safe food, which is currently being disposed of.

However, additional research and data are necessary in order to evaluate the quality of food, which for various reasons did not reach the recipient. It is advisable to carry out research confirming that these products, despite the failure to meet certain conditions, do not pose any threat to the consumer. Therefore, it is important to conduct simulation laboratory tests (variable conditions, e.g., temperature, humidity) to determine the impact of various factors on the safety of finished products.

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Appendix A

Questions included in the questionnaire to transport companies (without answers)

1. Please indicate the stages at which the driver of the transport unit is responsible for the goods.
2. Please indicate what type of exposure was the reason why the recipient did not accept the goods transported by your transport unit (even a small quantity). Please indicate the frequency and mass of such cases.
3. At which of the above-mentioned stages did the most frequent mechanical damage of transported goods occur.
4. Please describe the mechanical damage that caused the rejection of the goods by the recipient (specify the number of cases together with the weight/number of damaged goods).
5. Did contamination of the contents of one pallet included in the pallet unit due to the damage of a single package (the remaining pallets are clean) result in the recipient not accepting the entire transport package (pallet unit)?
6. Please indicate what happens to mechanically damaged goods not accepted by the recipient.
7. Does mechanical damage (dents or damage to single packages) occur in every transport?
8. Please indicate which products of the dairy cooperative, in your opinion, are most often subject to mechanical damage during transport (and not accepted by the recipient).
9. Does the customer check the temperature inside the loading space of the vehicle transporting the finished products to the dairy cooperative?
10. Please indicate the temperature ranges in the load compartment which are not accepted by the recipient (multiple answers possible).
11. How often is the temperature inside the load compartment taken and recorded during the transport of finished products of the dairy cooperative?
12. Does the consignee require the driver to show records of the temperature inside the load compartment of the vehicle transporting the finished products of the dairy cooperative?
13. Do cases of interruption of the cold chain occur during the transport of the dairy cooperative's products?
14. Please indicate the reasons for failing to maintain the cooling temperature in the load compartment of your company's vehicle (please indicate the frequency of such cases).

15. Please indicate the number of breakdowns and accidents that prevented the delivery of goods.
16. Please indicate the actions taken in the event that it is not possible to continue the route (breakdown/minor accident).
17. On the basis of which documents is compensation paid to your company by your insurance company?
18. Weight of products disposed of (kg).

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