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## **LEVEL OF FOOD LOSSES AND WASTE IN PRIMARY PRODUCTION IN POLAND<sup>1</sup>**

Key words: primary production, food waste, food losses, causes of food losses,  
reducing losses

**ABSTRACT.** The aim of the present paper is to show the results of the studies of food losses, as conducted in Poland in 2019, and to estimate the amount of food waste at a level of primary (agricultural) production in Poland during the years 2017-2018. Also, the differences between the food losses and food waste, based upon current definitions and legal regulations obligatory in Poland and the European Union, were indicated. The studies of food losses in primary production were carried out in the whole of Poland on a representative sample of 1,378 respondents from six sectors of the economy, with the utilization of a survey-questionnaire, using the PAPI (Paper & Pen Personal Interview) method. The mass of food waste was estimated on the grounds of the results of food losses and wastage, considering methods of management, excluding the destination for consumption purposes or animal feeds. From the conducted studies, it follows that the directions of management of food losses in primary (agricultural) production are different and are greatly dependent on the sector, i.e., the type of managed raw material, the causes of the resulting losses and the stage of production where the mentioned losses are generated. Food losses in agricultural production constitute 15% of total food losses in Poland, i.e., 749.48 thousand tonnes annually, whereas food waste is estimated at a level of 507.94 thousand tonnes per year. The appropriate management of losses in accordance with the hierarchy of proceeding with waste reduces the quantity of waste, decreasing, in effect, its negative impact on the environment.

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## INTRODUCTION

Food losses and waste should be treated as a global problem, manifested throughout the whole food chain, commencing from primary production, via after-harvest operations and storage, processing and distribution up to consumption in households and restaurants. The estimation of the level of food losses and waste at a national level in particular sectors or links and in the whole agri-food chain as well as the evaluation of the consequences of the mentioned phenomenon have not been the subject of complex studies in Poland until now; this was caused by the significant barriers concerning a lack of coherent definitions, a lack of adequate research methods and a lack of availability of data in the economic documentation of enterprises and institutions as well as in national statistics. The mentioned situation made the studies and comparative analyses on a global scale difficult and limited the possibilities of monitoring the discussed phenomena for economic and administrative needs and for the needs of national statistics.

When responding to the need of obtaining reliable and current data concerning food losses and waste in Poland and developing the research methods and research instruments, the studies in the PROM project (the development of the system for monitoring the wasted food and effective program for loss rationalization and the limitation of food wastage) have been carried out<sup>2</sup>. On the grounds of the conducted studies, food losses and waste in Poland were estimated at a level of 4,840,946 tonnes of food annually. The highest quantity, i.e., as much as 60% of the discarded food comes from households; primary (agricultural) production and processing account for 15% each [Łaba et al. 2020].

The Food and Agriculture Organization of the United Nations (FAO) informs that 931 million tonnes of suitable-for-consumption food is wasted annually all over the world; this constitutes 17% of food which was available to consumers in 2019 [UNEP 2021]. Food wastage is also becoming a more and more serious problem in Europe. According to the estimates, 88 million tonnes of food per year is wasted in the European Union – 173 kg per inhabitant, on average. The mentioned quantity is the equivalent of 20% of the whole food production in the European Union. Losses reach 143 billion EURO annually. Households account for almost 47 million tonnes of discarded food, with a value of EUR ca. 98 billion per year.

The reduction of food losses and food wastage in primary production will become a more and more important issue in upcoming decades. It will be aimed at supporting a sustainable nutrition model for the increasing world population [Busby, Hyman 2012].

<sup>2</sup> The project “The development of the system for monitoring the wasted food and effective program for loss rationalization and the limitation of food wastage (PROM)”, implemented within the frames of the strategic program of the research and development studies GOSPOSTRATEG, financed by the National Centre for Research and Development.

From a social viewpoint, food wastage is perceived as an obstacle in reaching the food safety level in starving regions of the world [Bagherzadeh et al. 2014]. In economic aspects, food wastage constitutes global costs, accumulated alongside the whole length of the food chain. The costs of one tonne of wasted food are considerably higher for the economy than the costs connected with the production of the aforementioned tonne of food. Food losses signify a loss of economic value for entities involved in food manufacturing and supply chains. The presentation of food losses and waste in categories of economic value is an important issue for policy and decision making [FAO 2011].

The cost connected with food wastage consists of at least two different types of costs: economic and environmental ones. The economic costs include not only the costs connected with the value of the products but also the costs relating to the primary production, transport and storage of waste and, additionally, the costs of their processing. From an environmental protection viewpoint, food waste signifies a lack of effectiveness in management if such resources as land, water, energy and other means at all stages of the life cycle of products as well as an increase in the emission of greenhouse gases, as its consequence [ETO 2016].

## THE DIFFERENCES BETWEEN FOOD LOSSES AND FOOD WASTE

In order to examine and calculate the scale of food losses and food waste, we have to properly determine both of the aforementioned categories. Unfortunately, the discussed definitions are alternatively used in respective literature, which is a serious error. According to the adopted legislation, waste is a part of the resulting food losses. In accordance with Art. 2 of the Regulation (EC) no 178/2002, “food” (or “foodstuff”) means any substance or product, whether processed, partially processed or unprocessed, intended to be, or reasonably expected to be ingested by humans. Food shall not include feed and live animals, unless they are prepared for placing on the market for human consumption, and plants prior to harvesting [Regulation (EC) no 178/2002].

The definition of “food” laid down in the cited above regulation encompasses food as a whole, along the entire food supply chain, from production until consumption. It also includes inedible parts which were not separated from the edible parts when the food was produced. In connection with this fact, food waste can comprise items which include parts of food intended to be ingested and parts of food not intended to be ingested (Motive of Preamble 2 to Delegated Decision 2019/1597 [EC 2019]).

According to Art. 3, p. 4a of the Framework Directive on waste, “food waste” means any food compliant with the definition of Art. 2 of Regulation (EC) no 178/2002, which became waste i.e., any substance or object which the holder discards or intends or is

required to discard (Art. 3, p. 1 of the Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives).

The mentioned definition does not include the losses originating from the stages of the food supply chain before the specified products became food, e.g., edible parts of plants prior to harvesting. The above interpretation, non-considering collected food waste as plants prior to harvesting, is consistent with the vision of the Protocol on food losses and waste, with which the European Commission wants to unify its reporting [FLW Protocol 2016]. The above intention also refers to the definition of food wastage of FUSIONS, which considers food waste from the moment “cultivations are mature for harvesting” [FUSIONS 2016a].

The following are excluded from the Directive obligations and, by this, from the definition of waste:

- by-products of animal origin, including processed products, with the exception of those intended for thermal treatment, storage at a landfill or are intended to be utilized in a biogas producing plant or in a composting plant (it refers to the products covered with Regulation (EC) 1069/2009 of 21 October 2009 laying down health rules as regards animal by-products and derived products not intended for human consumption and repealing Regulation (EC) No 1774/2002 (Animal By-products Regulation) [Official Journal of Laws of EU, L 300 of 14.11. 2009, p. 1, with later amendments]);
- dead animals that died on a farm in another way than slaughter, including animals that were killed for the purpose of eradicating diseases and that are disposed of in accordance with Regulation (EC) 1069/2009;
- substances destined for use as feedstuff materials.

According to the definition by FUSIONS [2014], food waste is any food, and inedible parts of food, removed from the food supply chain to be recovered or disposed (including composted, crops ploughed in/not harvested, anaerobic digestion, bio-energy production, co-generation, incineration, disposal to sewers, landfills or discarded to seas).

The status of waste, i.e., its qualification as waste or food waste is determined by its destination. If e.g., a cereal raw material, earlier intended for consumption, is destined for the production of animal feed due to unfavourable weather conditions or improper storage conditions (which caused a lowering of its processing value), it will not be qualified as waste or food waste. On the other hand, when it is destined for composting, it will be considered food waste steam.

## THE REASONS FOR GENERATING FOOD LOSSES AND WASTE IN PRIMARY PRODUCTION AND THE POSSIBILITIES OF THEIR LIMITATION

Primary (agricultural) production is the first link in the agri-food chain where – similarly as in the remaining links – food losses and waste take place. Primary production is the stage at which the mentioned phenomena are least recognised and, at the same time, most difficult to estimate. It results, first of all, from the fact that agriculture is dependent on varying and unpredictable weather conditions. The yields are different from year to year, their quality, level and form of agricultural products as well as the time of harvesting vary every year, as determined by atmospheric conditions as well as pests and diseases of plants and animals. The preferences and needs of the consumers are also subjected to changes, which is affected by many economic and non-economic factors. All mentioned factors are favourable for the generation of food losses and waste [Kwasek, Łaba 2020].

In primary production, the source of generated losses is different, depending on the plant or animal production. The main factors of losses include the limitations connected, *inter alia*, with the employed agricultural operations and the possessed infrastructure resources, used during production. Besides this, food losses and waste are also connected with the occurrence of various quality standards, which eliminate full-value products from the market, which do not meet so-called visual standards, such as e.g., an appropriate appearance, a uniform colour etc. [Kwasek et al. 2016].

In the discussed sector, the agricultural products that are not introduced to the market for human consumption are utilized for processing into non-food products, animal feed, bio-energetic purposes or soil betterment. When recognizing the positive effect of such activities, we may state that there is still considerable potential for improving the effectiveness of food production resources and solving the problem of food losses at a farm level.

Certain food losses resulting in primary production are unavoidable and, in connection with this fact, should be properly managed. The hierarchy of proceeding with waste is principally determined by a sequence of priorities, i.e., the best solution as regards legislation and policy concerning waste from the viewpoint of the natural environment. Deviating from the mentioned hierarchy may be necessary in the case of specified waste streams if it is justified, *inter alia*, by technical feasibility, economic profitability and natural environment protection [Official Journal of Laws of EU, L 312/3].

The first step in preventing waste generation includes a reduction of possible food losses [HLPE 2014]. As early as at the first stage of the agri-food chain, i.e., in primary production, a part of food products is not collected due to a failure to meet trade or quality requirements [Parfitt et al. 2010]. A part of the losses is generated during transport and

storage in agricultural farms; the essential element in their prevention is the optimization of production, storage and transport. Optimal storage management is connected with the management of resources [Borowski 2018]. The successive area of preventing food losses and waste generation – and by this, a reduction of the negative effect on the natural environment – includes redirecting non-commercial food in favour of persons in need and, in a further sequence – its destination for animal feed. The discussed food must, however, meet appropriate standards and not pose any danger to animal health, and indirectly to human health. If the discussed food does not meet any consumption requirements, we should consider options of processing which would have the smallest effect on the natural environment. It would include, successively, utilization by the industrial sector, as a recovery material, composting (use fertilizer) or processing into energy. Discarding (storage) food at landfills and its combustion is the last and least desired method for the disposal of food waste. From a natural environment viewpoint, it is the most negative form. All earlier mentioned measures should, however, lead to the smallest quantity of products, which will be directed to landfills [Kwasek et al. 2016, Borowski 2018]. Table 1 illustrates various methods for loss management, resulting from primary production in particular sectors of the Polish economy.

Reducing the scale of the discussed above phenomena is consistent with the implementation of the targets of sustainable development; the duty of the present generation is to take care of the fate and maintenance of next generations. The Member States of the UN have developed a document, called “Sustainable Development Goals 2030 Agenda”, containing 17 targets, which have subordinated particular tasks. Two from the goals of sustainable development (Goal 1 and 2) concern ensuring access to food for all people [PK UNESCO 2021]. Target 2 concern eradicating hunger, reaching food safety and ensuring access to food for people according to their needs. It also refers to promoting sustainable agriculture. Intensive agricultural production is one of the main factors having a direct impact on the natural environment (soil, water and air). It also contributes, *inter alia*, to the consumption of water resources, the contamination of water with fertilizers and pesticides, the erosion of soil and lowering their fertility and the emission of greenhouse gases to the atmosphere. The limitation of the negative effect of agriculture on the environment requires the introduction of cultivation methods and practices friendly to the environment [Janiszewska, Ossowska 2017].

Target 12 of sustainable development is aimed at elaborating the sustainable model of production and consumption. It is connected with many tasks, the first of which concerns the reduction of food waste by half *per capita* on a global scale in the area of retail sale, food consumption and the reduction of losses, generated in the process of production and distribution. It also refers to a decrease of losses occurring during the harvesting of agricultural crops as well as the appropriate management of the resulting waste [PK UNESCO 2021].

Table 1. The methods for the management of food losses and waste, generated in primary production in Poland in the years 2017-2018

Specification	The methods	
	main	sporadic
Cereal sector	composting, animal feeding, directing to a landfill, utilizing as biofuel, storing on manure, selling to other farmers for feeds, placing as bait for wild animals	directing to landfill, utilization as bio-fuel, storage on manure, sale to other farmers for feeds, placing as bait for wild animals
Sector seeds of oily plants (rape and common agrimony)	composting, animal feeding, directing to a landfill, animal feeding, directing to a landfill, biogas producing plants	animal feeding, directing to landfill, biogas producing plants
Fruit-vegetable sector	composting	–
Dairy sector	animal feeding, discarding (pouring out)	discarding (pouring out)
Meat sector	disposal	–
Fishing sector	fishery ground, further management, repeated sale, processing in farm, disposal, animal feeding, current consumption, predators	animal feeding, current consumption, predators

Source: [Kwasek, Łaba 2020]

Food losses, occurring during the stage of its production, are the important economic, environmental and ethical problems for the producers of food. When knowing the reasons of the loss generation, we are able to prevent it; on the other hand – depending on the management direction – losses become food waste or are utilized for circulation with a financial and an environmental profit. To undertake the appropriate preventive measures, we have to know the scale of the discussed phenomenon.

The aim of the present paper is to show the results of the studies of food losses, as conducted in Poland in 2019, and to estimate the amount of food waste at a level of primary (agricultural) production in Poland during the period of 2017-2018.

## MATERIAL AND METHODS OF STUDIES

The estimation of the quantity of food losses and waste at primary production was implemented on the grounds of preliminary studies conducted in the following sectors:

- cereal (consumption cereals);
- oil seeds (rape and common agrimony);
- fruit-vegetable;
- dairy;
- fishery (fishing farms);
- meat – red meat, i.e., pork, beef and poultry meat.

According to Art. 3, p. 17 of the Regulation (EC) 178/2002, primary production means the production, rearing or growing of primary products including harvesting, milking and farmed animal production prior to slaughter. It also includes hunting and fishing and the harvesting of wild products.

For the needs of the studies conducted under the PROM project, the initial moment was adopted as the moment when raw material becomes food [FUSIONS 2016b]. Cereals, being food, include cereal products harvested from the field for consumption purposes. The seeds of oil plants, fruits and vegetables become food, upon reaching the required maturity, are harvested from the field and are directed to storage houses destined for consumption. The stage before harvesting is not included in the losses and waste measuring system and, by this, food waste. Milk and dairy products, as food, are raw materials (products), obtained from fresh yielded milk and destined directly for consumption or application in the food industry. The fish, understood as food, included alive fishes, caught in the farm and directed to a storage reservoir, destined for the further distribution of processing for consumption purposes (in the case of sea fisheries since the registration moment in a harbour). In the case of primary production in the meat sector, food is constituted by animals from the moment it is destined for consumption (preparation for loading in order to direct it to the slaughterhouse) with utilization for food purposes. According to the motif of Preamble 3 to the Delegated Decision 2019/159 [EC 2019], food waste does not include losses at the stages of the food supply chain where certain products have not yet become food, as defined in Art. 2 of Regulation (EC) No 178/2002. When considering the above, the mentioned sector has not been considered in the estimation of food waste.

To get familiarized with the scale and estimate the level of generated losses, wastage and food waste, it is necessary to employ the appropriate research methodology, considering the specificity of a given sector and the particular links. On May 3, 2019, the European Commission adopted the Delegated Act laying down the common methodology for the measurement of food losses and waste [EC 2019]. It is aimed at the support of the Member States in respect of the quantitative determination of waste, food losses and wastage.



According to the recommendations of the European Commission, specified in the Delegated Decision 2019/1597 [EC 2019], in order to ensure the reliability and accuracy of food waste measurement, Member States should conduct measurements on a representative sample of the population, which the results are referred to, with the application of the respectively chosen methods. The methods employed in primary production, as recommended by the EC within the frames of uniform methodology include, as follows: direct measurement, mass balance, questionnaires and interviews, production coefficients and statistics and the analysis of waste composition [EC 2019]. The experience thus far shows that there is no universal method for data obtaining and their choice depends on the specificity of the particular stage or link of the agri-food chain where the measurement is to be carried out as well as on the purpose of the mentioned measurement.

The subject of the studies included agricultural farms and supplying raw materials for food production. The studies on food losses in primary production covered the years 2017 and 2018 and were conducted during the period of March – May 2019 in the whole of Poland, on a representative sample of 1,378 respondents from six sectors, applying the survey-questionnaire PAPI (Paper & Pen Personal Interview) method. The pollsters carried out the direct questionnaire interviews. For each sector, a separate interview questionnaire was prepared. It consisted of a few parts. The first one was a sort of certificate of a given farm, which characterised a given farm, as well as its type and method of farming/management. The successive part of the questionnaire concerned the level (size) of the crops/breeding level and mass (weight) of losses in the years 2017-2018. The successive part of the questionnaire included questions concerning the causes of losses and the directions of management as well as the organization of transport to the user. In total, there were 8 types of questionnaires employed for 6 sectors of the economy because, in the case of meat production, 3 types of surveys were developed: for poultry, pork and beef.

The employed method is recommended by the European Commission in compliance with Annex III of the Delegated Decision 2019/1597 [EC 2019] as regards common methods and minimum quality requirements for the uniform measurement of food waste levels.

In the conducted studies, before obtaining empirical data, the level and structure of the research sample, i.e., of agricultural farms, supplying raw materials destined for consumption purposes were defined. The randomly selected unit was a farm. There were 3 variants of the research trial with an assumed number of involved entities: 250, 500 and 1,000. Due to economic reasons, and the evaluation of adequacy and the assumed effectiveness of the planned studies, the decision on the choice of the randomized trial with 250 objects was undertaken. The structure of the trial was prepared with the assumption of its representative nature, depending on two most important characteristic features.

The classification into the following six sectors was also taken into consideration: meat, dairy, fruit-vegetable, cereals, rape and common agrimony and fish. The categorized size of farm (its area) and the region of the territory on which the given farm was situated were the characteristic classifiers of the farm. The fish sector was the exception, as – due to the specificity of inland fish farms – the data on the area of the fish farms were not available. In the case of sea fishing, it was implemented by entities acting as enterprises or by natural persons running economic activity. In connection with the above fact, the type of production conducted in a fish farm was chosen as the second classifying criterion of representative trials (apart from the situation in a given voivodeship).

A sample of 250 farms per sector was finally selected and the sampling strata were macro-regions. 1,378 sites from six sectors participated in the study. The number of respondents in individual sectors was similar to the assumed 250, except for the following sectors: fish, where 106 questionnaires were obtained, and meat, where 279 questionnaires were obtained, broken down into poultry, pig and cattle production.

Surveying was carried out directly by the pollsters – employees of the voivodeship and local Agricultural Advisory Centres (ODR). Six types of farms were chosen according to production: cereal, the cultivation of rape and common agrimony, fruit-vegetable, fisheries, dairy and meat (with the classification into poultry, pork and beef). The range of the studies included the determination of the quantity and type of food losses in particular farms and also the determination of reasons for the generation of losses and the directions of their management.

The results of the survey in primary production were collected in paper form and then, after checking and verifying, were introduced and aggregated in a specially prepared base of the MS Excel program in a way facilitating their verification and later analysis.

The mass of food waste (in tonnes), generated in particular sectors of primary production, was estimated based upon the results of food losses and waste obtained within the frames of the PROM project, with consideration of the management methods submitted in Table 2, excluding the destination for consumption purposes of animal feeds.

In compliance with the definition of “food”, as defined in Art. 2 of the Regulation (EC) 178/2002, the meat sector, in the link of primary production, was not subjected to analysis as regards food waste.

The calculated mass of food waste (tonnes) in the studied sectors of a given link in primary production was compared with the level of production in the examined sample of farms in the years 2017 and 2018. The obtained percentage level of food waste in a given sector was compared with the national amount of production, as published by Statistics Poland (GUS). To determine the quantities of raw materials produced for consumption purposes, the mean allocation coefficients were taken into account in the calculations.

Table 2. The methods for managing food losses and waste in primary production in Poland in the years 2017-2018, other than for the consumption of feed purposes

Specification	Methods
Cereal sector	composting biofuels biogas producing plants landfills
Sector of seeds of oily plants (rape and common agrimony)	composting biofuels biogas producing plants landfills
Fruit-vegetable sector	composting biofuels biogas producing plants landfills
Dairy sector	pouring out (discarding)
Fish sector	disposal

Source: own study based on IOŚ-PIB data

## RESULTS

Based upon the conducted studies under the PROM project, it was stated that the mean level of losses at primary production was equal to 1.45% of production; the mentioned losses differed, however, depending on the sector. Previously published research results from the PROM project show that the fruit and vegetable sector has the highest percentage of production losses, and the dairy sector has the lowest (Table 3) [Łaba et al. 2020].

The losses, estimated from a trial of 1,378 respondents, were extrapolated to a national level. Based upon the level of the total production of cereals and oily seeds in Poland (data obtained from Statistics Poland, GUS) and after considering the mean coefficients of allocation to the particular category, the quantity of the mentioned raw materials produced for consumption purposes in Poland was calculated. When assuming the mean values of losses in production farms in the particular sectors in relation to the production level destined for consumption, we may state that the mean level of losses at primary production in the selected sectors is equal to 749.48 thousand tonnes per year [Łaba et al. 2020].

Table 3. Losses at farms as a result of storage and other activities (average value for 2017 and 2018)

Sector	The mean level of losses in a farm		The share of losses in production [%]	The mass of food losses in primary production [thousand tonnes]
	tonnes			
Cereal	tonnes	0.91	1.7	219.60
Rape and common agrimony	tonnes	0.31	0.75	9.74
Fruit and vegetable	tonnes	3.83	3.89	479.67
Fish	tonnes	0.60	1.17	0.75
Meat	tonnes	0.80	1.02	12.74
Dairy	hectolitres	0.48	0.20	26.98
Average/Sum			1.45	749.48

Source: own study based on IOŚ-PIB data

The share of the particular sectors in the mass of losses, resulting in primary production, is dependent on the percentage of losses in production in a given sector and, also, on the level of production for consumption purposes in a given sector. The production of fruits and vegetables is mostly sensitive to losses; it reaches almost 4% of production; therefore, the mentioned sectors account for more than 60% of losses in the link of agricultural production. The smallest losses were revealed by milk producers; on the other hand, cereal production, which shows losses at a level of 1.7%, demonstrates – due to the scale of its production – 30% of losses in the link (Figure 1).

The main causes of losses in crop production were associated with the humidity regime (dampness, mold and rotting), as well as mechanical damage and pests. Other sectors have shown quite a wide variation in this area. In the fish sector, predators as well as natural and human factors were indicated. In meat production, the losses involved damage (mainly poultry), stress and diseases, which also had a significant share in losses in milk production. In addition to causes directly related to animals, milk losses also indicated impurities and inadequate temperature. Among the producers of the plant sectors, there were three main methods of managing the resulting losses: animal feeding, composting and landfilling. For the most part, the losses can be safely spent on composting or feeding animals. A landfill is, therefore, a method used as a last resort and occasionally. In the fishing sector, losses were mainly disposed of. Milk, due to its ease of management, was intended for feeding animals or poured. Losses and waste generated in the production of live meat cannot be managed or recovered because they must be disposed of.

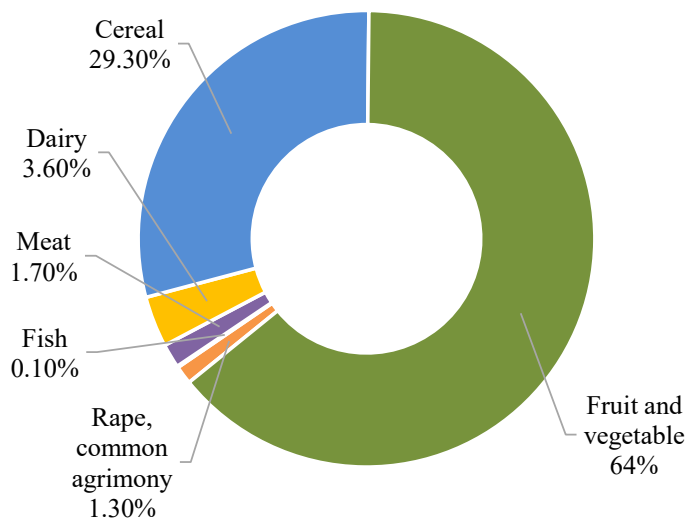


Figure 1. The share of the examined sectors in food losses in primary production  
Source: own study based on IOŚ-PIB data

Based upon the data concerning food losses in primary production and the way of their management, it has been calculated that the mentioned sector in Poland produces 507.94 thousand tonnes of food waste per year. The share of food waste as regards the level of production destined for consumption purposes is, on average, equal to 1.03%. It differs, however, considerably in the particular sectors from 0.13% in milk production to 2.37% in the production of fruit and vegetables (Table 4).

In the fruit-vegetable sector, the greatest amount of food waste is generated in primary production; it is connected with a high percentage of waste in the mentioned sector as well as the production scale. The cereal sector is also characterized by considerable participation as regards the quantity of the produced food waste.

From the conducted studies, it is followed that the directions of food waste management at the stage of primary (agricultural) production are different; they are greatly dependent on the sector, i.e., the type of produced raw material, on the causes of the losses and at the stage on which they are generated (harvesting, transport at the farm or storage). Most frequently, the methods of food loss management, as indicated by respondents, include: landfills, animal feeding, composting, bio-gas manufacturing plants, biofuels, disposal and sewage. According to the definitions cited earlier, food losses, which are used for animals (what is often employed at the discussed stage), come back to the circuit, whereas all remaining losses, irrespectively of the management method, constitute food waste.

Table 4. The mass of food waste in the examined sectors in primary production in Poland during the years 2017 and 2018

Sector	The share of food waste in the level of production in the examined farms [%]	The level of production in Poland destined for consumption purposes* [thousand tonnes/year]		The mass of food waste in the primary production [thousand tonnes/year]
		2017	2018	
Fruit-vegetable	2.37	15,259.74	15,571.48	365.12
Cereal	1.12	1,1333.38	9,506.90	117.24
Rape and common agrimony	0.65	1,213.79	991.08	7.22
Fish	0.87	53.30	48.70	0.45
Dairy	0.13	1,3704.15	14,181.04	17.92
Average/Sum	1.03	41,564.35	40,299.20	507.94

\* Based upon market analyses, carried out by IERiGŻ-PIB

Source: own study based on IOŚ-PIB data

Reassuming, the mass of generated food waste in relation to food losses is by 32% lower; it is just the same part of the losses directed to animal feeds. The remaining 68% of losses – which is differently managed – becomes waste.

The percentage share of the particular sector as regards the amount of the produced food waste in agriculture differs in comparison to food losses. The greatest participation, and at the same time, the highest quantity of the waste is generated by the fruit-and-vegetable sector; it constitutes as much as 72% of all waste in the discussed link of the whole chain (Figure 2). In spite of the fact that fruit and vegetables, as plants, are a very good raw material for feeds and could be used for animal feeding (it would reduce the quantity of waste in effect), the possibility of utilizing them in such a way is limited (rotting, moulding). Most of the lost food at the stage of primary production in the fruit-vegetal sector is directed to compost and biogas producing plants.

It is very difficult to estimate food losses in primary production and prevent these losses. Agricultural production depends on many external factors beyond the control of farmers, such as weather conditions or diseases. Depending on the adopted definitions, methods used or the region in which the research is conducted, very different results are obtained. The number of food losses in primary production in EU countries, estimated on the basis of various studies, ranged from 19% to over 34% [KOWR 2021].

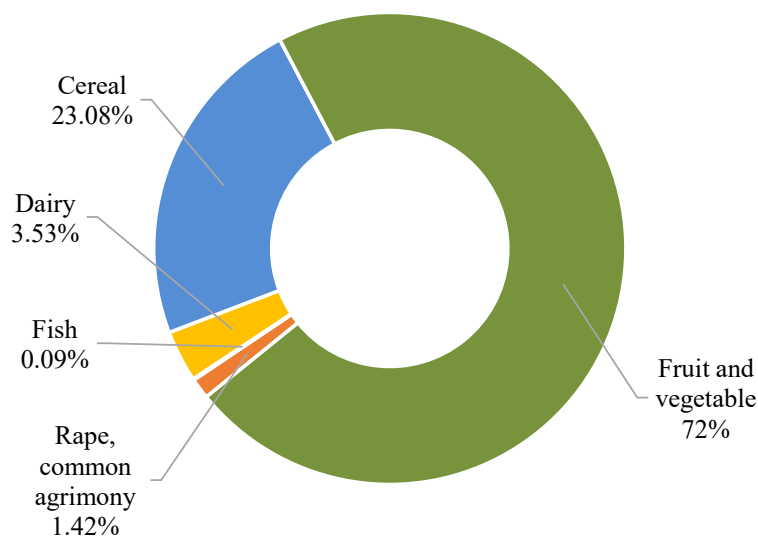


Figure 2. The share of the studied sector regarding food waste in primary production  
Source: own study based on IOŚ-PIB data

Research conducted as part of the PROM project shows that primary production was responsible for 15.5% of food losses in the entire food chain in 2017-2018 [Łaba et al. 2020].

These results slightly differ from those reported by other EU countries, which probably results from the use of different methods to measure the amount of food losses.

Food production uses natural resources but wasting food leads to environmental degradation. The environmental impact of produced food can be determined in terms of its “carbon footprint” by calculating the total greenhouse gas emissions during the full life cycle of a product. It is expressed as a carbon dioxide equivalent per functional unit of product ( $\text{CO}_2$  eq./functional unit).

On the basis of the calculated emission value for 2011, at a level of 3.6 Gt  $\text{CO}_2$  eq., and the level of food losses and waste in the world in the same year amounting to 1.3 billion tons [FAO 2014], the index can be calculated as 2,769 Gt  $\text{CO}_2$  eq./billion tons. Using this index, it is possible to determine the amount of Gt  $\text{CO}_2$  eq., which is generated annually by wasted food in Poland.

By comparing the amount of food losses in primary production in Poland to the assumed emission index, it was calculated that food losses in Poland during the year are responsible for the emission of 2,074 million tons of  $\text{CO}_2$ .

## SUMMING UP – CONCLUSIONS

Food losses generated in agricultural production in Poland constitute 15% of food losses in total, i.e., 749.48 thousand tonnes annually, whereas food waste is estimated at a level of 507.94 thousand tonnes per year.

Food losses and waste are generated by each sector of primary production in Poland, although in different quantities. It is important to prevent and minimize the generation of food losses and manage them in an appropriate way to minimize the food waste. The knowledge of the causes of their generation facilitates the introduction of preventive measures.

The appropriate management of losses, in compliance with the hierarchy of proceeding with waste, minimizes the quantity of the waste and, in effect, reduces its negative impact on the environment.

Primary (agricultural) production affects the natural environment *via* GHG emissions, the consumption of nutrients present in the soil, water resources, fertilizers and agents of plant protection as well as energy for the needs of agricultural operations. Limiting the mentioned effect requires, on the one hand, introducing more environmentally friendly practices and methods and, on the other hand, counteracting the losses of agricultural raw material and the resulting products. In the case that losses are generated, they should be managed in accordance with the hierarchy of proceeding with waste. The mentioned measures have a significant meaning for economic and environmental aspects as well as ethical ones.

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## POZIOM STRAT I ODPADÓW ŻYWNOŚCI W PRODUKCJI PODSTAWOWEJ W POLSCE

Słowa kluczowe: produkcja podstawowa żywności, odpady żywności, straty żywności, przyczyny strat żywności, ograniczanie strat

### ABSTRAKT

Celem opracowania jest przedstawienie wyników badań przeprowadzonych w Polsce w 2019 roku, dotyczących strat żywności oraz oszacowanie ilości odpadów żywności na etapie produkcji podstawowej (rolniczej) w Polsce w latach 2017-2018. Wskazano także różnice między stratami i odpadami żywności na podstawie aktualnych definicji oraz regulacji prawnych obowiązujących w Polsce i w Unii Europejskiej. Badania strat żywności w produkcji podstawowej przeprowadzono w całej Polsce na reprezentatywnej próbie 1378 respondentów z sześciu sektorów, z wykorzystaniem kwestionariuszy ankiety metodą PAPI (Paper & Pen Personal Interview). Masę odpadów żywności oszacowano na podstawie wyników strat i marnotrawstwa żywności z uwzględnieniem sposobów zagospodarowania, wyłączając przeznaczenie na cele konsumpcyjne lub na pasze dla zwierząt. Z przeprowadzonych badań wynika, że w produkcji podstawowej (rolniczej) kierunki zagospodarowania strat żywności są różne i w dużej mierze zależą od sektora, czyli rodzaju wytwarzanego surowca, przyczyn, które te straty powodują oraz etapu, na którym powstają. Straty żywności powstałe w produkcji rolniczej stanowią 15% strat żywności ogółem w Polsce, tj. 749,48 tys. ton rocznie, natomiast odpady żywności oszacowane są na poziomie 507,94 tys. ton rocznie. Odpowiednie zagospodarowanie strat, zgodnie z hierarchią postępowania z odpadami, minimalizuje ilość odpadów, zmniejszając w efekcie negatywny wpływ na środowisko.

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