Fundamental elements of the food waste reduction process. The case of agritourism pensions in Romania

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Abstract:

Food waste is a generalized process that affects both the environment and resources (natural, financial, sanitary, etc.). The negative effects are felt both at the individual level (household budget) and at the society level, and they are, as a rule, difficult to combat. From the existing quantitative and qualitative analyses, it was observed that food waste at household level represents over 50% of its total volume, even if food waste is produced throughout the supply chain. It is also noted that some economic sectors, by the nature of their activities, have a greater predilection to waste food (eg HoReCa or large retail stores). The case study carried out concerning the agro-tourist guesthouses in the mountainous area of Romania showed that, at their level, food waste has a reduce dimension. This is due to the household spirit and the ethical and spiritual values passed down from generation to generation, to which is added the love and respect for Romania's mountains.
Solutions to reduce this phenomenon take different forms of manifestation, from awareness of the phenomenon itself to rethinking portions, promoting good practices, innovative packaging, etc. Considering the above, the article aims to contribute to a better knowledge of the phenomenon of food waste and to the identification of viable solutions by which this phenomenon can be tackled.

Key-words: food waste, sustainable development, smart packaging, food behaviour, Mountain Area, agro-mountain tourist pensions

Abstract:
Risipa alimentară este un proces generalizat, care afectează, deopotrivă, mediul înconjurător și resursele (naturale, financiare, sanitare etc.). Efectele negative se resimt atât la nivel individual (bugetul gospodăriei), cât și la nivel de societate, ele fiind, de regulă, dificil de combătut. Din analizele cantitative și calitative existnte s-a observat că risipa alimentară la nivel de gospodărie reprezintă peste 50% din volumul total al acesteia, chiar dacă deșeurile alimentare se produc pe întreg lanțul de aprovizionare. Se observă, de asemenea, că unele sectoare economice, prin natura activităților, au o predilecție mai mare de a risipi alimente (de ex., HoReCa sau marile magazine de retail). Studiul de caz realizat în articol, care a vizat pensiunile agro-turistice din zona montană din România, a arătat că, la nivelul acestora, risipa alimentară prezintă o dimensiune redusă. Aceasta se datorează spiritului gospodăresc și valorilor etice și spirituale transmise din generație în generație, la care se adaugă dragostea și respectul față de munții României. Soluțiile de reducere a acestui fenomen îmbracă diferite forme de manifestare, de la cunoștientizarea menului în sine și până la regândirea porțiilor, promovarea unor bune practici, ambalaje inovative etc. Având în vedere cele menționate, articol își propune să contribuie la o mai bună cunoaștere a fenomenului risipei alimentare și la identificarea de soluții viabile prin care acest fenomen să poată fi combătut.

Cuvinte cheie: risipa alimentară, dezvoltare durabilă, deșeuri alimentare, ambalaje inteligente, comportament alimentar, Zona montană, pensiune turistică agro-montană

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Introduction

Along with the multiple challenges that exist globally (population growth, pandemic crisis, geo-political crisis, climate change, land use pressures, etc.), there is a worrying phenomenon that is worsening and increasing: food waste. At the same time, the reduction of food waste determines a series of positive effects for society: reducing costs with natural resources, making food consumption more efficient, combating environmental pollution, etc. Thus, the estimates made by FAO concluded that, annually, the global cost associated with food waste reaches 2.6 trillion USD (equivalent to 3.3% of world GDP), and the benefits obtained can be in the form of the economy of certain resources (to water, for example, reach 250 billion tons of water annually), reducing or avoiding the application of some fertilizers, alleviating the pressure on cultivated land (Kummu et al., 2012; Vanham et al., 2015). It is estimated that at least 170 million tons of CO_2 equivalent are emitted annually as a direct effect of food waste (about 3% of the total greenhouse gas emissions in the European Union), of which over 80 million tons of CO_2 equivalent are caused of food waste produced in households.

In this context, reducing food waste becomes a legitimate target and a key priority of public, local, regional, national and global policies, but also a wish for every assumed inhabitant of the planet. This aspect is even more relevant in the context of the sustainable development goals established by the United Nations Organization, which advocates a "responsible consumption/production, which leads to a 50% reduction in food waste per capita globally, by the year 2030" (ONU, 2015).

In the European Union, under the auspices of the cohesion policy, food waste is addressed within the program called *zero waste*, launched in 2018, which supports active collaboration in order to monitor and reduce food waste throughout the supply chain (EC, 2018).

In Romania, annual food waste amounts to 2.5 million tons, each citizen wasting, on average, 70 kilograms annually, a figure that places Romania in the middle of the European ranking. The Ministry of Agriculture and Rural Development estimates that the food industry sector generates 37% of the waste, public food about 5%, and the agricultural sector 2%. Thus, food is thrown away even if there is a number of over 4.6 million Romanians threatened by poverty (November, 2021) and an important percentage of the population is below the poverty line (low work intensity, in conditions of severe material deprivation).

Taking into account the above, the article aims to inventory the main ways of general assessment of food waste and to analyse it for the agro-pensions in the mountain area. Following the analyzes carried out, a series of measures and actions have been identified that can contribute to supporting public or private interventions in their fight against this global phenomenon.

1. Metodology

The elaboration methodology consisted in:

1. literature review analisys according to certain keywords (food waste, food waste, etc.); a synthesis was made and interpretations were made by the authors;
2. selection of specific indicators;
3. analisys and interpretation of statistical data using Excel;
4. discussions and interviews with the owners of agro-mountain pensions.

2. State of the Art

The recognition of the importance of reducing food waste is reflected in academic literature, but also some practical approaches, the relevant objectives being to examine the causes and sources of production (Schanes et al, 2018), monitoring (Corrado and Sala, 2018), methods control and mitigation (Cristobal et al, 2018) etc.

The economic literature in the field focuses, in particular, on the short-term (Campoy-Munoz et al., 2017), but also on the medium term (Rutten et al., 2013a) effects, showing that the quantitative impact of reducing food waste is usually analyzed through a system-wide macroeconomic simulation, an approach that explicitly recognizes the direct impact on different stages of the production and supply chain. In the studies identified, and as a result of the lack of statistical data, the results are based, in most cases, on estimates of the phenomenon. Thus, most of the time, the supply perspective of the phenomenon is ignored or reduced in terms of labelling, packaging and logistics within the food chain. At the same time, assessing the quantities and value of food waste remains a challenge (Bellemare et al., 2017) mainly caused by the lack of data and statistical information. The uncertainty behind the problem of food waste is also given by the fact that there is no accepted assessment methodology at the level of the member states, but also by the fact that there are different definitions of food waste (Scherhaufer et al., 2018; Schneider, 2013).

In support of the above, we mention here the conclusions of a study developed by Corrado and Sala (2018), which shows that the measurement of food waste flows on a European and even global scale can vary significantly depending on the choice of assessment methodologies, the inconsistent use of definitions, of the fact that food waste can be "avoidable or unavoidable" (Lebersorger și Schneider, 2011).

Food waste at EU level per capita varied on a scale between 158 kg and 298 kg per year per capita. Added to these are estimates of 76 kg per capita per year (Monier et al., 2010 based on 2006 data for the EU27) or 92 kg per capita per year (Stenmarck et al., 2016 based on 2012 data for the EU-28, this includes edible and inedible scraps).

A question that arises is the assessment of the benefits and costs resulting from the reduction of food waste (FAO, 2014, Schanes et al. 2018). It is argued that microeconomic theory often fails to capture "real" consumption behavior, which arises from non-value (non-price) factors, including erroneous planning decisions, perceptions of aesthetics, and social ones such as prestige, but and the relationship between purchasing power and food options or those related to nutritional value (Segrè et al. 2014).

Cultural factors or related to lifestyle (determined by culinary, nutritional knowledge, food management, storage, etc.) are also difficult to assess, but also those related to ethical, ecological and cost perceptions of food waste in societies where food is abundant at relatively low cost. Food labeling and packaging also fall into this category of factors (a study shows that in the US, about 37% of consumers always or usually throw away food that is close to the date stated on the package under the name "best before" (Neff et al. 2019).

Some specialists (Williams et al. 2012) estimate that food losses due to packaging reach 20–25%, demonstrating that bulk packaging and date labeling are important factors in food waste. Therefore, it is logical to infer that innovations in food packaging and labeling (e.g. resealable, smaller and sub-divided packages, more detailed advice on the label, time-temperature indicators and control) are key factors in reducing household waste. There is even a perception that clearer indications on packaging can limit the additional cost for the retailer (Verghese et al. 2015) or increase the benefits associated with incentive taxation (Schanes et al. 2018).

The benefits of reducing food waste are not confined to a specific sector or area, but cover both upstream markets (e.g. feed, fertilizer use, land and labour) and food security benefits from reducing food imports.

Food waste assessment models are diverse. In an attempt to standardize them, a group of FAO experts (2014) specialized in food security propose a general equilibrium framework model that should be followed in case of food waste. They start from the theory of general equilibrium, in which market exchanges are based on the price system. The concept of "equilibrium" refers to the fact that such exchanges take place in such a way that all actors are satisfied and can produce new exchanges. The theory of general equilibrium is based on perfect competition (Arrow and Debreu, 1954) and certain working assumptions: there must be at least one price system, which equalizes the (global) offers and demands of economic agents (agents who behave as "participants at the price").

Other examples in the relevant literature call for macroeconomic simulation models (e.g. fixed-price social accounting matrix; Campoy-Munoz et al., 2017) or computable general equilibrium representations under flexible prices (Britz et al., 2014; Rutten et al., 2013a; Rutten și Verma, 2014; Rutten et al., 2015; Rutten și Kavallari, 2016).

Other methods by which food waste can be assessed are identified in the table below.
Table 1. General methods for evaluating food waste in each economic sector

<table>
<tr><th>Economic Sector</th><th colspan="6">Evluation methods</th></tr>
<tr><td>Production</td><td rowspan="4">Direct Measurement</td><td rowspan="4">Waste composition analysis</td><td rowspan="4">Volume assessement</td><td rowspan="2">Quality asessement</td><td></td><td></td></tr>
<tr><td>Comerce</td><td rowspan="2">Numbering, scanning</td><td></td></tr>
<tr><td>Food services</td><td></td><td rowspan="2">Food Journal</td></tr>
<tr><td>Households</td><td></td><td></td></tr>
</table>

Source: No time de waste. Why the EU needs to adopt ambitious legally binding food waste reduction target?

At EU level, each member state has developed specific instruments aimed at reducing, managing and preventing food waste. Some take the form of National Waste Plans, but also different waste prevention strategies or programs.
In conclusion, estimating the amount of food waste per country is relatively difficult to achieve, as food waste is often collected together with other waste and therefore cannot be recorded separately. This is mainly true for household waste, but also for other sectors where food waste could be collected and treated as bio-waste. Even more difficult is estimating the amount of food waste that can be avoided. To determine the generation of avoidable and time-consuming food waste, the most used methodologies refer to separate sorting, which is often difficult to achieve.

3. A possible model of cost-benefit analysis applicable to the phenomenon of food waste

According to the most recent data published by the National Institute of Public Health (year 2019), in Romania, food waste is estimated at 6,000 tons per day, 50% coming from households, 37% from the food industry, 7% from retail, 5% from public food and 2% from the agricultural sector.
To combat this phenomenon, the Food Waste Prevention Law no. 217/2016 (corroborated with the provisions of Law no. 227/2015 on the Fiscal Code) covers the following measures:

1. responsibility for reducing food waste in the agri-food chain;
2. sale at a reduced price of products close to the expiry of the minimum durability date;
3. transfer of food by donation, for human consumption;
4. disposal and use of animal by-products and derived products;
5. directing agro-food products that have become unfit for human or animal consumption by turning them into compost;
6. directing agro-food products that have become unfit for human or animal consumption in order to capitalize on them by transforming them into biogas;
7. directing to an authorized waste neutralization unit.

The measures presented above carry additional costs, generated by changes in the production process that can be partially or fully recovered through a reduction in food waste.
An analysis of the effects of such measures at the national level requires examining the basis of food waste formation, in order to determine the places and directions for improvement, including their cost. Given the fact that food waste generates different costs considered disproportionate at the level of production sources, we believe that a Cost-Benefit Analysis model applicable to the evaluation of this global phenomenon can be considered.
From this perspective, we propose a food waste evaluation model, based on cost-benefit analysis (CBA), with the following stages:

- strategic approach and definition of objectives;
- identifying and selecting the most suitable alternative;
- plan of measures (financial estimate);
- economic analysis;

- performance indicators;
- sensitivity and risk analysis.

The strategic approach considers the establishment of the following possible *objectives*:

- developing an annual plan to reduce food waste,
- carrying out internal communications with employees from different sectors on this topic,
- adapting production to certain existing market situations (demand-offer, ensuring traceability),
- waste reduction plan depending on the market and the place where it is produced,
- plan of education and information measures regarding the prevention of food waste,
- ways to quantify food waste,
- measures to redistribute/use benefits (where possible).

Cost-Benefit Analysis (CBA) seeks to compare costs now and future benefits. Typically, either the net present value (NPV) or the internal rate of return (IRR) is calculated. Proposed waste reduction projects are accepted if the NPV is positive or the IRR is greater than the average interest rate.

The purpose of CBA is to compare the economic costs of the plan of measures to reduce waste with the economic benefits that will be obtained at an updated social rate (usually 5%). In practical terms, this is expressed by the CBA's economic performance indicators: a). Net Economic Present Value (NEPV), b). The benefit / cost ratio (B / C) and c). ERR (economic rate of return).

Economic costs (as opposed to financial ones) are measured in terms of "resources" or "opportunity costs" (the benefit that must be given up by the alternative use of a resource).

Similarly, benefits can be measured in terms of the amounts that people are prepared to pay (willingness to pay) or, alternatively, in the costs of avoiding an environmental problem as a result of implementing a plan to measure. Also, the external benefits that result from the implementation of the plan of measures to reduce waste and that are not captured by the analysis carried out in financial terms must be identified.

There are a number of costs that must be taken into account when doing economic-financial analyses. Thus, economic costs represent the broadest category that includes: financial costs, resource costs, environmental costs etc.

The *identification of the economic costs* has three phases (Table 2):

- Phase 1 – corrections related to taxes, subsidies, other transfers;
- Phase 2 – corrections related to externalities;
- Phase 3 – conversion of market prices into accounting prices to include social costs and benefits (determination of conversion factors).

Table 2. Costs – calculation phases

Phase 1 – fiscal corrections	This phase consists in determining two elements for the economic analysis: the value of the fiscal correction and the value of the conversion factor for market prices affected by the fiscal policy. Since market prices include taxes, subsidies, but also some transfer payments, it is difficult to estimate net values and therefore general rules will be used to correct these distortions: the prices of inputs and outputs for the cost/benefit analysis will not include VAT or other indirect taxes; raw material prices must include direct taxes; transfer payments to individuals, such as social insurance payments, must be omitted from the calculation; in some cases, indirect taxes/subsidies are intended to correct externalities, such as environmental taxes included in the price of energy and fuel, and in such a case their inclusion in project costs may be justified, provided that double accounting is avoided; standardized factors can be used for some classes of inputs and outputs (financial flows).

Phase 2 – externalities correction	Included in this category are the costs and benefits derived from environmental impact assessment, CO2 emission estimation, etc. In this sense, a list of quantifiable externalities can be used. When calculating the economic rate of return, quantifiable aspects can be taken into account.
Phase 3 – conversion of market prices into accounting prices	In this case, the conversion factors for the transformation of market prices into economic values are determined. Apart from fiscal influences and externalities, the real prices of raw materials and final production can be distorted by the imperfections of market mechanisms.

Source: own interpretations.

Distortions related to the wages of those involved must be taken into account when calculating the costs of waste sorting activities, especially those working with environmental protection infrastructures. Current wages can be a distorting social indicator for the opportunity costs of labor (as a result of labor market imperfections).
The calculation of the economic performance indicators is done after the correction of price distortions. After choosing the social discount rate, the net discounted value (NDV) and the benefit/cost ratio can be calculated. The difference between the economic rate and the financial rate is that the former uses opportunity costs instead of prices from imperfect markets and includes, as far as possible, social and environmental externalities. Because of positive externalities, many projects may have a low or negative financial rate of return and a positive economic rate of return.
As recommended (European Commission Guide, 2014), the economic discount rate that can be used is 5%.

Calculation of CBA indicators
I. Net Economic Present Value (NEPV)
Based on the data and the net income flow, the net present value can be calculated:

$$VNAE = \sum_{t=0}^{n} a_t S_t = \frac{S_0}{(1+r_a)^0} + \frac{S_1}{(1+r_a)^1} + \ldots \frac{S_t}{(1+r_a)^t} \ldots + \frac{S_n}{(1+r_a)^n}$$

where S_n is the balance of net income flows (cash flow) over time ***n***

$\boldsymbol{a}_t$ is the balance of net income flows (cash flow) over time

$\boldsymbol{r_a}$ is the discount rate (5%).

II. Internal Rate of Return
Internal Rate of Return (IRR) is defined as the interest rate for which the net present value of the investment is equal to zero.

$$VNAE = \sum_{t=0}^{n} (S_t / (1+RIRE)^t) = 0$$

$$RIRE > 5\%$$

The value of the two financial indicators can be calculated relatively easily with the help of financial functions from the EXCEL program, or based on other specialized financial management programs, by applying appropriate functions.

III. Benefit/Cost Ratio (Profitability Index - PI)
It is calculated as a ratio between the updated value of benefits and costs. The report must be supra-unitary.
PI = Present benefits/presents costs

The benefits of reducing food waste

When estimating the benefits resulting from the reduction of food waste, three methods of analysis can be taken into account: qualitative, quantitative and monetary.
Qualitative estimation investigates the types of benefits that should result. For this, each category of food waste can be examined, although in some cases the benefits increase from combined measures to combat waste.
The main resulting benefits can be the following:

•health benefits (reduction of illnesses, avoidance of premature mortality, etc.);
•benefits regarding resources (economies of resources from forestry, agriculture and fishing);
•ecosystem benefits (benefits on some parts of the environment without commercial interest);
•social benefits (food bank, donations, etc.);
•extended economic benefits: local and regional development (attracting investments), eco-efficient gains, development of new sectors (eco-packaging);
•the economic benefits resulting from the more efficient use of some resources.

Where possible, these benefits should be quantified and, furthermore, monetary estimates of them should be presented (noting at each level the assumptions and interpreting the results).
As a result of the difficulty of assigning monetary values to benefits (in some cases it is relatively difficult: for example, how much does the peel of an apple, egg, etc. cost), economic estimates cover fewer benefits. That is why it is important that each level of analysis is seen as providing value by itself, and that the qualitative assessment is not seen only as a step towards the quantitative one. Focusing only on monetary analysis would result in missing out on some of the benefits. With each step - from qualitative to quantitative analysis, to certain monetary values - the volume of benefits changes in the sense of diminishing them.

4. Results and discutions

4.1. Evaluation of food waste from mountain agro-pensions in Romania

An important place in the entire food chain is occupied by food waste in the HoReCa sector, given that in order to increase its turnover, the sector forces the sale through large portions of food that remain unfinished and through an oversupply in order to increase attractiveness. Part of food waste is caused by products that are cooked and left uneaten due to the lack of proper facilities.
In Romania, per capita estimates of food waste are 70 kg/year, with urban areas producing more food waste, while in rural areas there is a tradition of consumption without much loss as a result of a high ethical sense, but also relatively low incomes and the use of traditional methods of valorizing household food scraps.
The estimation of food waste took into account the interviews carried out in 2021 with the owners of agri-pensiones in the mountain area in Romania, from which it was found that this percentage reaches about 15 kg of waste per tourist (about 21.4% of the national average of 70 kg per per capita, annually). Given that this was a maximum value, and taking into account the trends identified at national level (food waste decreased in 2020, compared to 2016, in all product categories, with significant percentages in bakery products: decrease of 63, 8% compared to 2016, as with meals prepared at home - decrease of 61.11% compared to 2016), the following analysis hypotheses existing in national studies were selected:

1. in restaurants, food waste is estimated at 15 kg per tourist per year;
2. in catering companies - 6 kg per tourist per year.

The estimation of food losses in mountain tourist in Romania structures was carried out on the basis of the following work options and took into account that not all mountain tourist structures have their own restaurants:

a. *10 kg per tourist annually food waste produced in the average mountain areas;*

b. *15 kg per tourist per year, maximum option;*
c. *6 kg. per capita annually minimum variant of waste produced in tourist accommodation structures*.

4.2. The situation of tourist structures in mountain areas in Romania

The tourist capacity of the mountain areas (year 2021) was 2,492 tourist accommodation structures, which represents 27.25% of the total at the national level. About 52.85% of the total are agro-tourist guesthouses, followed by tourist guesthouses (17.47%), tourist villas (8.47%) and hotels (7.95%). Most are 3 stars and are agro-tourist guesthouses (Figure 1).

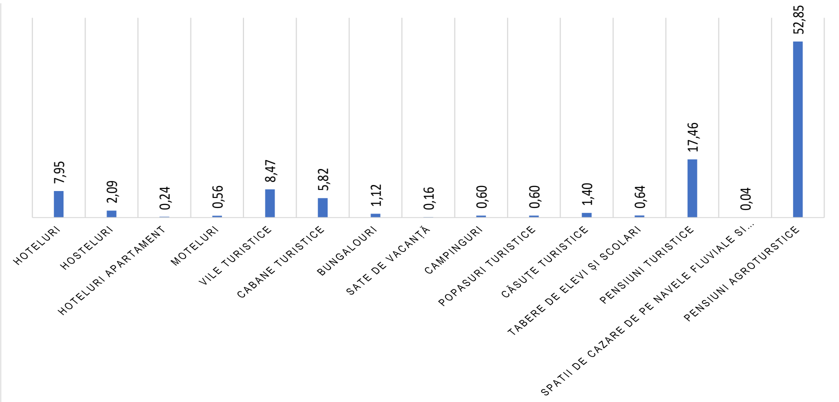

Figure 1. Turistic structure by types of accommodation, Romania, 2021 (%)
Source: own processing of INS data.

There are 66,374 accommodation places in the tourist accommodation structures in the mountain area (with an average of 27 places per tourist unit). About 32% of places are in agritourism guesthouses, followed by hotels (26.58%) (Figure 2).

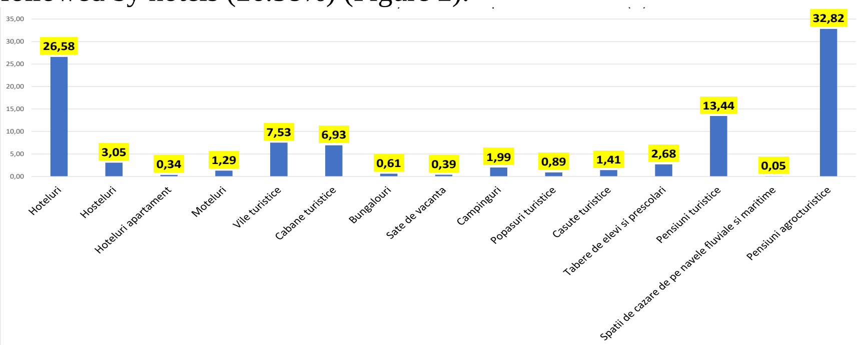

Figure 2. The structure of accommodation places in tourist units in the mountain area, Romania country, 2021 (%)
Source: own processing of INS data.

Figure 3 shows the arrivals (number of people) in the tourist reception units in the mountain area. It can be seen that there were 1,866,402 people in 2021, 44.6% more than in 2014.

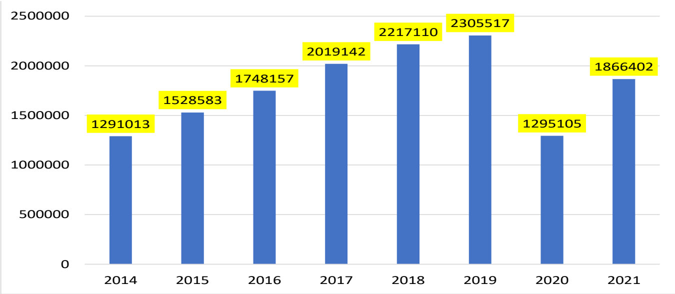

Figure 3. Arrivals of tourists in tourist reception structures in the mountain area, Romania, 2021 (no.)
Source: own processing of INS data.

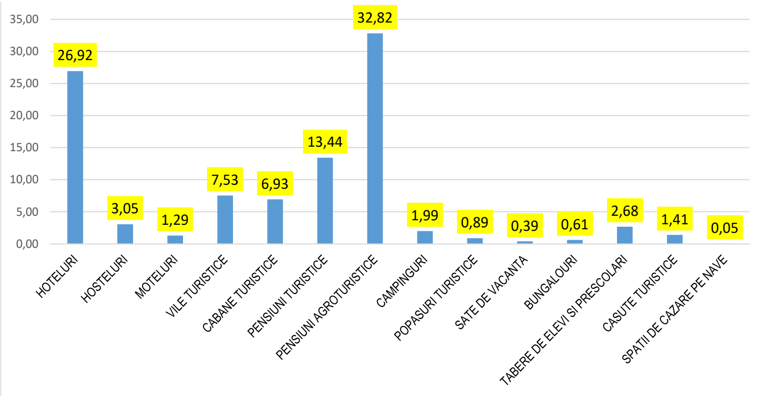

Figure 4. Places - bed in tourist structures in the mountain area, Romania, 2021 (%)
Source: own processing of INS data.

As can be seen in Figure 5, mountain tourist structures had an average degree of occupancy in 2021 of 42.5%, the most occupied being hotels (52.8%), followed by tourist villas (36.5%) . Mountain agro-tourist guesthouses had an occupancy rate of 23.1%, while tourist guesthouses were occupied at a rate of 26.2%.

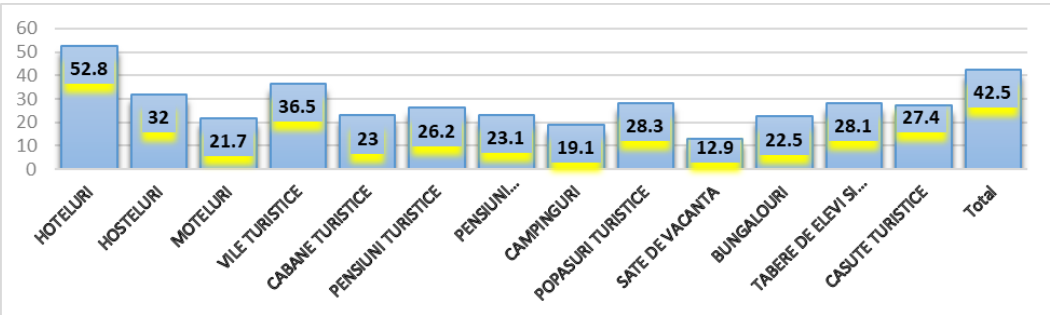

Figure 5. The degree of occupancy in mountain tourist structures, Romnaia, 2021 (%)
Source: own processing of INS data.

Taking into account the previously presented elements, Table 3 presents the estimates regarding the amounts of food waste in the analyzed mountain areas in Romania, within the tourist structures. Thus, the most estimated waste is produced in hotels in the mountain area (95.8 tons annually maximum and 57 tons minimum), followed by agro-tourist guesthouses (36 tons maximum and 21 tons minimum.
According to estimates, the units in the HoReCa sector register over 250,000 tons of food waste thrown to the landfill annually (12%-15% of the total food waste). Compared to the total value estimated for

the HoReCa sector, the food waste in the mountain area has a small size, it represents 0.0144% of the estimated 250,000 tons (the maximum value of the waste in the mountain area).
In conclusion, starting from these global estimates, we believe that a more accurate assessment of the quantities of food waste is necessary, which takes into account each activity sector separately.
Moreover, it is necessary to standardize the amount of waste for each sector, so that the estimate is as close as possible to the real situation (Table 3).

Table 3: Estimates of waste quantities (annual), Mountain Area, Romania Country

			TOTAL estimated food waste per year		
Accomodation type	Total beds	Effectively occupied beds taking into account the degree of occupancy	10 kg per capita	15 kg per capita	6 kg. per capita
Hotels	18.159	9.588	95.879,52	143.820	57.527,7
Hostels	1.463	468	4.681,6	7.022,4	2.809,0
Motels	1.150	250	2.495,5	3.743,25	1.497,3
Turistic villas	4.341	1.584	15.844,65	23.766,98	9.506,8
Tourist cottages	4.037	929	9.285,1	13.927,65	5.571,1
Tourist guesthouses	8.137	2.132	21.318,94	31.978,41	12.791,4
Agritourism pensions	15.549	3.592	35.918,19	53.877,29	21.550,9
Campings	1.152	220	2.200,32	3.300,48	1.320,2
Tourist stops	491	139	1.389,53	2.084,295	833,7
Holiday villages	310	40	399,9	599,85	239,9
Bungalows	369	83	830,25	1.245,375	498,2
Pupil and preschool camps	1.673	470	4.701,13	7.051,695	2.8+20,7
Touristic houses	420	115	1.150,8	1.726,2	690,5
Total	39.092	16.614	166.141	249.211,5	99.684,6

Source: own processing of INS data.

Moving forward with the analysis, it is found that not all structures in the mountain areas are equipped with restaurants or shops, the most important are hotels (34%), agro-tourist guesthouses (22%) and tourist guesthouses (20.13%).
This aspect complements the previous conclusion, in the sense that food waste is produced, in particular, in tourist structures that also have restaurants or shops.

4.3. A scenario with high potential impact on reducing food waste. Innovative packaging

The packaging process is vital in maintaining the quality and safety of food, but also in extending the shelf life of the stored product, thus reducing food waste. However, packaging is, in turn, a product with a short life cycle, therefore its incorrect management can lead to negative effects on the economy and the environment.
Packaging has a direct link to the circular economy, which promotes closing the loops in industrial systems, minimizing waste and reducing the input of raw materials and energy. From the perspective of the circular economy, the food chain includes three important stages: food production, consumption and food waste generation, including food surplus management.

Currently, the food journey "from farm to consumer" shows the need for packaging systems that facilitate the protection, transport and storage of food products. In this context, packaging could significantly contribute to reducing food waste. Therefore, it is recommended to continue the development of new forms of distribution packaging for food products, which minimize handling along the supply chain.

Some forms of packaging, such as reusable boxes and pallets, offer a solution that minimizes product handling. Food and packaging have a unique relationship. By using food packaging correctly, the amount of food waste in households can be minimized, with environmental effects caused by overproduction.

That's why it's important to recognize the potential trade-off between packaging consumption and food waste. In this sense, it is well known that packaging contributes to sustainable development by maintaining the quality of products in the supply chain.

There are studies showing that packaging can be an interesting and attractive topic because people have become more aware of packaging waste than food waste (they usually underestimate the amount of food waste).

Packaging is one of the most studied methods of reducing food waste, an important concern being the impact on the environment versus the generation of waste. For example, the shift to single-serving formats in certain food categories may result in a high volume of packaging per unit mass of food, even though the potential for food waste generation is low. It becomes essential to recognize and investigate the trade-off between packaging consumption and food waste to produce the best environmental outcome.

Packaging can be classified as follows:

➢ Primary packaging for retail (plastic, glass, metal, etc.).

➢ Secondary/tertiary packaging: additional layers that contain and protect the primary packaging during distribution (examples: corrugated cardboard boxes, plastic or wooden pallets, plastic crates for processed foods or stretch films).

The most used materials are polymeric (37% - in the flexible version 10% and rigid 27%) due to the properties that can ensure the quality of the packaged products throughout their lifetime until consumption. The types of polymer packaging are: trays, boxes, casseroles, bags, films, sealable foil, cups, vacuum bags etc.

These types of packaging must comply with certain specific quality conditions for the entire duration of both transport and the life of the food products.

To determine packaging-related food loss, it is necessary to identify the stages of the packaged food supply chain. Within the supply chain, there are several stages and reasons why food can be wasted:

After a product is packaged (for transport or sale), the packaging can lead to the loss of contents.

The packaging must present a series of characteristics, for example they must be easy to open and empty. If these characteristics are not met, food waste occurs quickly (by spillage).

An estimate based on studies showed that food loss and food waste caused by packaging contributes with 20-25% of the total amount of household food waste (Table 4).

Table 4. Types of food waste caused by packaging damage

Phase	Types of food waste caused by packaging damage	
On the supply chain	Post-harvest handling and storage	Damage caused by various contaminants, sharp edges, chips from storage containers.
	Processing and packaging	Problems in the filling process; Packaging failures during sealing; Changes to packaging for marketing reasons.
	Distribution	Inadequate packaging material, poor stability; damage to barcodes

In households		Packaging difficult to open or empty; Incorrect size.

Source: https://iba-riscuriambalaje.ro/wp-content/uploads/2020/09/Strategie_risipa_final.pdf

According to European Regulation 450/2009, the main design criteria that an ideal package must fulfill are: zero toxicity, easy handling, adequate mechanical strength, firm closing characteristics (such as resealing), moisture control, appropriate labeling.
The main benefits of reducing food waste by using innovative packaging are:

- Save money by reducing overbuying and disposal costs;
- Reduces the impact on the environment;
- Supporting efforts to eliminate hunger;
- Reduction of health-related problems; elimination of odors;
- Supporting community efforts to reduce waste;
- Increasing fiscal benefits through food donation;
- Energy conservation and reduction of greenhouse gases.

Food safety is also taken into account. Thus, microbial contamination of food products is still the main cause of food-borne diseases. Additional challenges are given by the globalization of markets, which require products with longer shelf lives, as well as the growing demand for minimally processed foods. Therefore, there is a need to develop innovative food packaging materials that guarantee safety and maintain quality for longer periods of time.
To meet these challenges, food packaging technology is constantly evolving. Table 5 presents some possible technological innovations to prevent food waste, from the perspective of packaging.

Table 5. Technological innovations in food packaging to prevent food waste

Improved packaging properties: mechanical, thermal, barrier properties
Biodegradability: increased biodegradation
Active packaging: shelf life extension, oxygen scavenger, antimicrobial
Smart packaging: interaction with the environment, self-cleaning, self-healing, damage indication
Controlled delivery and release: nutraceuticals, bioactive compounds (such as essential oils)
Product condition monitoring: temperature time indicator (TTI), freshness indicator, leak indicator, gas detector
Nanosensors: indication of food quality, growth of microorganisms
Nanocoatings
Product information: nano-barcode, product authenticity.

Source: Love Food Hate Waste (2018) A-Z of food storage.

Thus, the role of food packaging must change from a passive one (a simple container that protects its contents from moisture, air, microbes and mechanical damage such as vibrations and shocks) to an active one, able to extend shelf life by interacting with product (e.g. by releasing antioxidants, antimicrobials or oxygen scavengers).
Collaboration and data sharing in the supply chain can be facilitated by "smart" or "interactive" packaging technologies. Smart food packaging can provide real-time expiration data, product tracking and temperature indicators, which are either time-based or triggered by certain chemicals, determined by radio frequency identification (RFID) data, or have thermal sensors, to provide better demand feedback for various supply chain actors. These smart packaging technologies have the potential to reduce food waste in the supply chain by sending information back to suppliers regarding quality, safety, shelf life and logistics efficiency.
This information can be used to reduce the time products spend in the supply chain, thereby extending shelf life and reducing the likelihood of product spoilage in transit or storage.

In these conditions, nanotechnology is increasingly being explored as a tool for the development of active food packaging. Thus, NanoPack is an active packaging film with antimicrobial properties, which slowly releases small amounts of antimicrobial essential oils in the form of vapors into the so-called "headspace" of the package, thus sanitizing both the food product and the headspace and extending the shelf life of the product. NanoPack films are able to extend the shelf life of bread without additives by 3 weeks, demonstrating the potential of active packaging systems to reduce food waste.
High barrier packaging materials (plastics and metallized films) are increasingly in demand as they provide a strong mechanical barrier and are resistant to water, oxygen and pathogens and therefore can extend shelf life using fewer preservatives. Some materials are often produced from non-renewable fossil-based sources and are not biodegradable.
Sustainable disposal or recycling methods are often limited for materials containing many different functional layers. In addition, the environmental impact of persistent plastic packaging waste, in particular, is of general concern worldwide. As such, there is a growing trend towards more sustainable options with less impact on the environment.
Bio-based packaging materials are increasingly explored as ecological substitutes for traditional plastic packaging due to their increased biodegradability or compostability. However, their industrial use and application is still limited due to their properties (e.g., increased permeability to water or air). These properties must be greatly improved if traditional plastic is to be replaced and the waste problem managed.
An example of good practice is the RefuCoat project, financed by EU funds, which proposes the development of two new types of bio-food packaging. The first is a fully recyclable active packaging replacement for the metallized foils currently used in the packaging of cereals, crisps and salty snacks. The second is a fully biodegradable package for chicken products.
Active packaging systems allow food to be transported for longer, minimizing loss and waste associated with food spoilage, while other innovative ideas allow waste to be reduced or turned into valuable resources. These technological innovations can be a crucial tool in the global fight against food waste.
Another innovative idea to increase the sustainability of food packaging is to turn it into a by-product of the food industry. Thus, YPACK, a community project (2017) is developing a fully recyclable packaging film and a fully biodegradable packaging tray, using by-products that would normally be wasted, such as unpurified cheese whey and almond shells. The associated flow pack film acts as a passive barrier and the tray has active antimicrobial properties capable of extending the shelf life of food products.
Taking into account the fact that plastic packaging is found everywhere in nature around the world (in ocean waters, rivers, mountains, forests, cities, etc.) and the fact that much waste can no longer be sorted or recycled, we believe that the impact of a smart packaging would be great.
To stop this waste from expanding on a large scale, it is important that certain laws are passed to protect the sale of bags and other packaging made of plastic or non-renewable materials.
In Romania, Law no. 87/2018 promulgated on January 1, 2019 regarding the management of packaging and packaging waste prohibits the sale of plastic bags (thin plastic bags with handles, 50 microns thick). In order to reduce the presence of these bags and to interfere with the illegal system of buying surplus bags in other countries, it is important to change the green tax. As a result, plastic bags have been partially removed from the commercial system and replaced with biodegradable and compostable bags, which are more environmentally friendly. The costs vary starting from 0.10 lei/bag and reaching 0.15 lei/bag. The problem is the incorporation of natural safeguards, which are intended to include thin plastic bags without handles.
The SR EN 13432: 2002 standard applies to products that meet certain standards in the field of biodegradable and compostable objects. Therefore, to be approved, the packaging must meet certain criteria: aa have a shelf life of 12 weeks until the product degrades almost completely. Except for carbon dioxide, a biodegradable bag emits no harmful substances into the atmosphere.

There is a difference between biodegradable products and compostable products: biodegradable items are not entirely beneficial to the environment. They also have plastic components and microorganisms that help break it down. Compostable items are made from organic materials such as cornstarch. Therefore, if such objects or packages, including bags, are used more and more, nature has many benefits.

Conclusions

In conclusion, the specialized literature in the field focuses, in particular, on the short-term (Campoy-Munoz et al., 2017), but also on the medium term (Rutten et al., 2013a) effects, showing that the quantitative impact of reducing food waste is usually analyzed through a system-wide macroeconomic simulation, an approach that explicitly recognizes the direct impact on different stages of the production and supply chain. In the studies identified, and as a result of the lack of statistical data, the results are based, in most cases, on estimates of the phenomenon. Thus, most of the time, the supply perspective of the phenomenon is ignored or reduced in terms of labelling, packaging and logistics within the food chain.

At EU level, each member state has developed specific instruments aimed at reducing, managing and preventing food waste. Some take the form of National Waste Plans, but also different waste prevention strategies or programs. Also, estimating the amount of food waste per country is relatively difficult to achieve, as food waste is often collected together with other waste and therefore cannot be recorded separately. This is mainly true for household waste, but also for other sectors where food waste could be collected and treated as bio-waste. Even more difficult is estimating the amount of food waste that can be avoided. To determine the generation of avoidable and time-consuming food waste, the most used methodologies refer to separate sorting, which is often difficult to achieve.

Taking into account the presented elements in Chapetr 4, the most estimated food waste is produced in hotels in the mountain area in Romania (95.8 tons annually maximum and 57 tons minimum), followed by agro-tourist guesthouses (36 tons maximum and 21 tons minimum. According to estimates, the units in the HoReCa sector register over 250,000 tons of food waste thrown to the landfill annually (12%-15% of the total food waste). Compared to the total value estimated for the HoReCa sector, the food waste in the mountain area in Romania has a small size, it represents 0.0144% of the estimated 250,000 tons (the maximum value of the waste in the mountain area). Starting from these global estimates, we believe that a more accurate assessment of the quantities of food waste is necessary, which takes into account each activity sector separately.

Moreover, it is necessary to standardize the amount of waste for each sector, so that the estimate is as close as possible to the real situation.

The present article tried to give a brief picture of what the phenomenon of food waste means and the importance of actions that address, directly or indirectly, its reduction. Thus, the recognition of the importance of reducing food waste is reflected in academic literature, but also some practical approaches, the relevant objectives being the examination of the main causes and sources, continuous monitoring and promotion of control and reduction methods.

By reducing food waste, many benefits can be obtained: for health (reduction of diseases, avoidance of premature mortality etc.), resource savings (resource savings from forestry, agriculture and fishing), ecosystem benefits, social benefits (food bank, donations) etc.

It has also been found that the use of certain packaging that uses different innovative materials can lead to a number of benefits, such as: saving money by reducing overbuying and disposal costs, reducing environmental impact, supporting efforts to eliminate hunger , reducing health-related problems; eliminating odors, supporting community efforts to reduce waste, increasing tax benefits through food donation, conserving energy and reducing greenhouse gases.

In conclusion, regardless of the means or tools to reduce food risk, it is necessary, first of all, to be aware of the size and intensity of the phenomenon and must be acted upon as such. Decision-makers, together with individual consumers, production or marketing units, must work together to identify the best solutions and measures, which ensure the achievement of the goal of reducing food waste per capita by 50% globally, at the level of the year 2030" (ONU, 2015).

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