INVESTIGATION OF FOOD WASTE GENERATION

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Abstract

According to the Food and Agriculture Organization of the United Nations (FAO), up to one third of all food is lost or wasted worldwide throughout the supply chain. It must be investigated how much food waste is generated in the whole food chain in reality, are consumers really responsible for the majority of food lavish, what are the main reasons for food waste and how can we minimize spoilage. In this review article a wide outlook of papers is given, published about food waste in last two years. It has been concluded, that additional data are needed to get a clear picture about the real quantities of wasted foods, because the available data are inconsistent.

In the reviewed papers, a lot of action have been published about how to reduce food wastage, starting from innovation in the industry, logistics, through creation by-product exchanges, development of demand forecast and product packaging, etc. up to substantial improvement of food literacy of the population. It is evident, that these actions will have some effect. In this case, the quantity and proportion of food waste will change, thus, the generation of waste is

dynamic. If it is dynamic, it can be modelled and forecasted on the basis of models created in future. In this way the research question can be answered.

Keywords: food waste, waste in food supply chain,

Összefoglalás

A FAO adatok szerint a világon az élelmiszerek harmada hulladékká válik az ellátási láncban. Meg kell vizsgálni, hogy valójában mennyi hulladék képződik a teljes élelmiszerellátási lánc egyes szakaszaiban, valóban a fogyasztók felelősek-e túlnyomórészt az élelmiszerveszteségért, illetve melyek az élelmiszer veszteség fő okai és hogyan lehet minimalizálni a pazarlást. E referatív cikk áttekinti az utóbbi két évben megjelent tudományos cikkeket. Megállapítást nyert, hogy további adatokra van szükség az elpazarolt élelmiszerek pontos mennyiségének meghatározásához, mert inkonzisztensek a rendelkezésre álló adatok.

E cikkben sok élelmiszerhulladék csökkentési akcióról olvasható az ipari és logisztikai innovációtól a melléktermék tőzsdén, igény-előrejelzés modell, valamint a csomagolás fejlesztésen át a lakosság élelmiszertudatosságának növeléséig. Evidens, hogy ezek nem maradnak hatás nélkül. Ebben az esetben viszont az élelmiszerhulladék mennyisége és a képződés helye szerinti aránya is változik. Ha pedig ez dinamikus, akkor modellezhető és a mennyisége és mennyiségi arányai előre jelezhetőek a jövőben. Így a kutatási kérdés megválaszolható.

Kulcsszavak: élelmiszer hulladék, hulladék az élelmiszerláncban

Introduction

According to the Food and Agriculture Organization of the United Nations (FAO), up to one third of all food is lost or wasted worldwide throughout the supply chain. This corresponds to about 1.3 billion tons per year and represents a waste of resources, water, energy, land, and other inputs used for producing that food, including labour (Gustavsson et al. 2011). For Europe, different estimates are highly uncertain, mostly due to: different methods for quantifying food waste exist, different databases for the calculation are used (e.g. FAOSTAT and EUROSTAT), and a lack of harmonization in the nomenclature (Cristóbal et al. 2018).

Thanks to the recent Circular Economy (CE) package (EC 2018), food waste prevention has gained prominence in the European political debate. In fact, the CE Action Plan (EC 2015) included food waste within the so-called ‘‘priority areas”, i.e. areas that should be carefully considered to strengthen the circularity of the European economy.

The EU policy can, and has, led to significant amounts of avoidable wastage of fresh fruit and vegetables. However, the reforms of policy, even of those not specifically focused on food waste, such as the CAP, can have a positive impact on reducing the volumes of such loss and waste (Porter et al. 2018).

The subject of food loss and waste prevention recently gained much attention and priority among governments and international organizations, as a major means to achieve global food security and sustainability; this led to the very ambitious UN goal SDG12.3, which aims to halve global food losses by 2030 (Rosa 2017).

The target of this article is to review scientific literature about current results, used methods and further research proposals which must be considered in answering the research question.

How much food waste is generated in the whole food chain in reality, are consumers really responsible for the majority of food lavish, what are the main reasons for food waste and how can we minimize spoilage.

a) There is a notable inconsistency in data about food waste available from different sources,

b) The quantity and proportions of waste is not static, the dynamics can be modelled.

Results and Discussion

General factors

The research question and hypothesises are in accordance with conclusion of earlier studies, for example must be investigated (Muriana 2017): (1) Forecasting the food waste and loss by means of holistic-adaptive models, (2) Defining the analytical conditions responsible for the food waste and loss generation, (3) Redesigning the supply chain management models, (4) Verifying the affordability of food waste and loss management systems.

Food waste definitions and system boundaries need to be carefully selected and communicated in a transparent manner, as the chosen definition and system boundaries will impact the final results and conclusions (Hartikainenet al. 2018).

Both consumer behaviour and production practices play crucial roles in the efficiency of the food system. The substantial losses occurring during livestock production, and reveals the magnitude of losses from consumption of food in excess of human nutritional requirements. The greatest rates of loss can substantially affect the overall efficiency of the food system, and associated environmental impacts (e.g. greenhouse gas emissions) (Alexander et al. 2017). An

integrated metropolitan food systems and corresponding food policy and planning are gaining ground in the wake of growing urban populations, changing diets and consumption patterns, and with sustainable agriculture and food supply chain innovations and solutions to potentially reduce urban footprints and vulnerability to global changes. Thus, quantitative estimates about the relationship between food demand and regional production conditions are required to inform and support the design of food policy (Zasada et al. 2017).

A waste reducing plan needs to question the unlimited right to produce waste and orient waste producing actors toward waste prevention. A hard way could be to regulate through environmental permits the amount of waste that every business is allowed to generate. A softer way could be to financially promote waste prevention initiatives with a high effect on waste generation. However, this requires tools for evaluating the waste prevention effect of initiatives and balancing the three disparate parameters of waste prevention – quantity, impact, or hazardousness (Johansson et al. 2018).

A range of recurrent organizational factors may have an impact on reducing food waste in a causal sense, including: food market competition; impact of food imports upon customers; standardized food regulations; easy, open, low cost food market entry (easiness of market access); level of bureaucracy; working with local charities; one unified food authority; time to market; collaboration between food authorities and supply chain stakeholders (Irani et al. 2018).

The challenges food characteristics, supply chain uncertainty, food policy and regulation, and market infrastructure were determined to be the ‘key’ challenges inhibiting the reduction of food waste in Indian agri-food supply chain (Gokarnet al. 2017).

Food industry

A nontrivial amount of food loss is being attributed to the industrial/production level. An advantage of industrial food waste is that it is generally a more homogeneous resource that can be more readily converted into higher value products (RedCorn et al. 2018).

Industrial/production level was mentioned earlier. One possible way of reducing wastes is the developing of By-product Exchange Networks. They can transform the existing system - to sell waste as by-product, which will be used as raw material - into a much more effective one (Raabe et al. 2017).

Others (Raak et al. 2017), on the basis of case studies, made in Germany, concluded, that the causes of food waste generated during food processing are underrepresented in the scientific literature. They intend to fill these gaps by interviewing representatives from the food industry. The identified causes may be categorized as follows: (i) Losses resulting from processing operations and quality assurance; and (ii) Products not fulfilling quality demands from trade.

The innovation is most important in food industry. One example is described by (Matar et al. 2018), as shelf life modelling. Other example for innovation, in milk industry, less waste is generated from one product, if it has a longer shelf time (Spadaet al. 2018). Another example concerns the waste reducing effect of intelligent packaging (Poyatos-Racionero et al. 2018, Ahmed et al. 2017). Packaging has an effect too. The shape of box determines, how much product will be left unused, simply it will remain in box (Meurer et al. 2017). Innovation should prevail be in technology of production process too, because this can lead to less waste generation (Mustafa et al. 2017). Nonthermal plasma technology as an innovative procedure,

that can be used with a some favourable effect on packed food, reducing waste generation (Hati et al. 2018).

As the labelling (including date printing and electronical label reading solutions) has an important effect on food waste generation, the actors of food industry are stakeholders too, they bear a big responsibility (Wilson et al. 2017, Thompson et al. 2018, Chen et al. 2017).

The farming conditions and slaughtering technology have an effect on the meat industry waste generation, through confiscating (Jaja et al. 2018).

Food supply chain

Food loss is an issue in the upstream stages of the supply chain, with rates varying from 3 to 12%, depending on the sector (Broekmeulen et al. 2017, Ju et al. 2017). Food waste can be reduced, for example, with the Dynamic Industry Resource Efficiency Calculation Tool (Verghese et al. 2018). Other researchers found inconsistency in data regarding the generated wastes in supply chain (Cicatiello et al. 2017; Chaboud 2017). On the basis of 26 German case study initiatives tackling consumer food waste, these can be categorized into three main categories: (i) information and capacity building initiatives aimed at supporting consumer motivation and ability to avoid food wastage. (ii) redistribution initiatives as 'classical' foodbanks or consumer led actions (iii) supply chain initiatives, as actions by conventional retailers or other established or new actors in the supply chain, that tackle food waste through altering retail sale or the supply chain functioning (Aschemann-Witzel et al. 2017). The root causes of food waste generation are well known yet (Teller et al. 2018).

Innovation plays an important role in supply chain too. For example, the ultrasonic humidification can reduce the post-harvest losses of selected fruits and vegetables in Europe

by up to 23% compared to conventional supply chains. (Fabbri et al. 2018) The controlled atmosphere of storage, with increased CO_2 content in air, leads to longer shelf life (Alamar et al. 2017). Other waste reducing innovations are the using of wireless technics and RFID solutions (Badia-Melis et al. 2018, Lorite et al. 2017). The demand forecast with modelling is a good up-to-date tool to reduce leftovers (Birisci et al. 2018). Waste likelihood is higher when food items are purchased via online (vs. in-store) grocery channels, (Ilyuk 2018) and in delivery system too (Fikar 2018). Waste could be reduced in shops with lowering storage temperature (Erikssonet al. 2016) and in whole supply chain (Zhao et al. 2018). The computer assisted ordering (CAO) or automated order systems (ASO) can be evaluated as innovative solutions too (Haijema et al. 2018).

New business models (for example social co-op project, Fruta Feia, developed in Portugal) change the paradigm in society regarding the consumption of fruits and vegetables following aesthetic rules, because the food waste due to aesthetic reasons is a problem in most developed countries (Ribeiro et al. 2018, de Hooge et al. 2018). In this paragraph reprocessing must be mentioned the, e.g. frying the fresh meat leftover in meat shop (Kawata et al. 2018). Food bank activity becomes wider and wider (Sewald et al. 2018).

Expiration date-based pricing as a food marketing approach for foods currently wasted at the retail stage should become a practice perceived favorably by consumers. In consequence, it can become more efficient and widespread, allowing to save greater quantities of food from wastage with less resource use and effort. As an implication for consumer behaviour research literature, the findings do not confirm a negative quality inference of price reduced suboptimal food nor the counteraction provided by the positive quality inferences tested, but in turn underline the relative role of familiarity (Aschemann-Witzel 2018). Expiration date based pricing was mentioned by other authors too, using "dynamic pricing" expression

(Adenso-Díaz et al. 2017, Buisman et al. 2017). But in other cases several marketing actions, as promotion can lead to the increasing of food wastes (Le Borgne et al. 2018, Swaffield et al. 2018). Bigger On Shelf Availability may be evaluated as marketing activity and leads to more waste (Broekmeulen et al. 2017).

Developed logistics solutions can reduce food wastes in the whole agri-food chains by taking back the leftover (Fancello et al. 2017). Other authors state it as preferences of take-back agreements (Eriksson et al. 2017). The route optimization in emergency and everyday cases is another logistics possibility to reduce wastes (Mejjaouli et al. 2018, Mercier et al. 2018).

In several countries administrative policies lead to reducing of food waste. Tax credit and disposal fee are substitute mechanisms for inducing food donation (Lee et al. 2017). In Sweden, on the basis of cost-benefit analysis, it is suggested to include promotion of food waste reducing investments into policies (Mattsson et al. 2018).

HORECA

School Lunch Policies must content time and duration of lunch, because they effect on quantity of food waste (Chapman et al. 2017), because more structured lunch breaks lead to less plate waste (Steen et al. 2018). It must be promoted by awareness campaigns to reduce food (and inorganic) waste in canteens (Pinto et al. 2018). Others found key food waste determinants (i) top management standpoint towards food waste and sustainability in general (ii) relevant differences among the catering business models, (iii) diverse resource availability among the schools. The human factor arose as the most relevant one when aiming to minimize food waste (Derqui et al. 2018). The environmental and personal determinants are

interrelated and that the impact of different determinants is relative to perceived time constraints during a visit of the university canteen (Lorenz et al. 2017).

Restaurant food waste per capita per meal varies considerably by cities, consumer groups, restaurant categories, and purposes of meals (Ling-en et al. 2017, Lingen Wang et al. 2018). At EU level, restaurants occupy the second highest position in the classification of bodies responsible for food waste generation and a significant share of restaurant costs "goes" to waste (Principato et al. 2018). But majority of people were not aware of the environmental impacts of restaurant operations (Sarmiento et al. 2018). The personal characteristics, together with situational factors, are determinants in workplace cafeterias too (Sebbane et al. 2018). In particular, food waste generation per meal can likely be limited by: promoting and using local, fresh, and quality food; standardizing and limiting daily menu items; basing food recipes on consolidated cooking knowledge and experience; and limiting plate sizes. The monthly variation can be explained by high working pressure of consumers and the closing of a seasonal business - typical for restaurants in tourist areas (Tatàno et al. 2017). Three-quarters of restaurants avoided food donation because of unfounded fear of the legal liability (Sakaguchi et al. 2018). Bulk of research exist on food donation, that studied the phenomenon from the perspective of food donors. The perception of recipients, especially their willingness to accept donated food, remains under-examined, and yet there is anecdotal evidence that people have the tendency to assist, rather than to accept social assistance (Filimonau et al. 2019). There is a double paradox between conflicting norms and emotions: personal norms encourage not to waste while salient social norms encourage leaving leftovers; asking for a doggy bag generates immediate shame while leaving leftovers produces anticipated regret and guilt (Sirieix et al. 2017). In several cases food is taken away to workplaces or delivered to there. Management of take-away waste in workplaces has become a serious problem in

Chinese cities while the separation of the mixed waste is regarded as a promising solution (Liao et al. 2018).

In hospital the room service improves nutritional intake and increases patient satisfaction while decreasing food waste and cost (McCray et al. 2018). It was concluded by other authors too, completed with changing 3-meals per day to 6-meals (Ijmker-Hemink et al. 2017).

Households

A lot of articles were published about food waste generated in households. It is regulated by quite other interactions. Earlier research works started from Theory of Planned Behaviour (Ajzen 1991). The short essence of it is, that the intention will not be rejected by attitudes or subjective norms or perceived behavioural control, then it will be carried out, for example: not to waste.

This model defined, that attitudes and other norms determines the food wastage up to 35%. So, food-related routines (i.e. planning, shopping and leftovers reuse) are main drivers of food waste in addition to perceived behavioural control. Among the routines, the leftovers reuse routines are the most important contributors to food waste but are closely followed by shopping routines. Planning routines contributed only indirectly through shopping routines. These routines were closely associated with households' perceived skills. Nevertheless, the psycho-social factors included play a role as well (Stancu et al. 2016).

In another article (Diaz-Ruiz et al. 2018) a combined approach was mentioned, assembling current evidences on the relevance of food and environmental behaviours as well as selected consumer values to explain consumers' food waste generation. The results, obtained from their model, confirmed the hypothesis, that food waste behaviour is a complex issue that

needs to be analysed with an integrative approach. Overall, the main results suggest that consumers' purchasing discipline, waste prevention behaviours and materialism values are useful direct predictors of food waste behaviour. Specifically, high and committed waste prevention behaviour influences to declare low food waste generation. But others include strong latent factors too (Ponis et al. 2017).

Particularly, in Hungary, it was also confirmed that income has an effect on food waste production that varies by foodstuff categories: bakery product waste was mainly dominant for middle income consumers and fresh fruits were typically wasted by more affluent households. Apart from that, higher income resulted in higher food waste production in general (Szabó-Bódi et al. 2018).

Conclusion

This review article has achieved its own target, it gives a wide outlook of papers, published about food waste in last two years. The research question is confirmed at the necessary level. Both hypothesises were confirmed. Additional data are needed to get a clear picture about the real quantities of wasted foods.

In the reviewed papers, a lot of action have been published about how to reduce food wastage, starting from innovation in the industry, logistics, through creation by-product exchanges, development of demand forecast and product packaging, etc. up to substantial improvement of food literacy of the population. It is evident, that these actions will have some effect. In this case, the quantity and proportion of food waste will change, thus, the generation of waste is

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