Considerations on food losses in Life Cycle Approach of food supply chain

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ABSTRACT

With a per capita consumption in Europe of more than 700 kg of food (without beverages) per year, a considerable amount of time, money and resources is spent in producing, processing, transporting, buying, preparing and eating various kinds of food. Thus, food consumption produces an important environmental impact and numerous life cycle assessment studies have already been conducted, dealing with the environmental impact of specific food products, diet options or food on national level. Further to the overall results of these research activities, it is interesting to observe how food losses occurring throughout the life cycle of food are considered. The paper discusses the different data bases used to assess food losses and presents three examples to illustrate how different authors dealt with the problem of food losses within their life cycle assessment studies. The impact produced on the environment by food losses manifested during different waste management options is also illustrated.

Introduction

Food is an essential part of our everyday life; it affects physical and mental ability, health, well being and social integration and is influenced by tradition, religious beliefs, ethical considerations, etc. With a per capita consumption in Europe of more than 700 kg of food (without beverages) per year, a considerable amount of time, money and resources is spent in producing, processing, transporting, buying, preparing and eating various kinds of food. Thus, food consumption produces an important environmental impact and numerous life cycle assessment studies have already been conducted, dealing with the environmental impact of specific food products, diet options or food on national level [see 1, 2, 3]. Studies from Sweden, Denmark and US found that food products belong to the five most resource-demanding and polluting product groups [3].

Further to the overall results of these research activities, it is interesting to observe how food losses occurring throughout the life cycle of food are considered. Food losses begin on the farm where selective harvesting is performed, leaving small or misshapen products in the field. In the food processing industry, both wholesale and retail, numerous products have to be discarded due to spoilage, overstocking, improper packaging, damage or expired shelf dates. On household level different kinds of food waste are produced such as preparation discards, plate waste, spoiled food and products with expired shelf dates. Food products are discarded only partly consumed or even unopened. While preparation residues can be estimated more easily, being the inedible part of the food (e.g. outer leaves of a head of lettuce), the amount of uneaten wasted or partly used food is difficult to determine.

This paper discusses the different data bases used to assess food losses and assumptions concerning food losses by reviewing various LCA studies from literature for several food products, diet options or national food supply systems. Efforts made to produce food subsequently wasted are illustrated with an example. The impact produced on the environment by food losses manifested during different waste management options is presented to show the potential effects. The large quantities of food surpluses wasted within LCA for countries or larger regions are also discussed.

Data base for estimation of food losses

Food losses are often estimated using databases generated for other purposes whereas direct and indirect methods can be distinguished. As the availability of food is essential for the health and wealth of the population, countries carefully watch the national and international food market, keeping records on national food production, as well as import/export of food. Thus, statistical data on the amount of available food within a nation is available for the majority of countries. This does not imply that the amount available will be consumed as a whole; indeed, only part is actually eaten by the population. One explanation of losses is represented by the non-consumable parts of food such as bones included in the slaughtering weight of animals. Another part is removed during processing, transport, storing and preparing of food or ends up as plate waste. If data from supply balance sheets are converted into available nutrition energy per capita and year, the result is much higher than the recommended level as well as that actually registered. The latter would lead to a significantly overweight population, a fact hard to verify however from a medical point of view. Hence, losses occurring along the food path from the available amount recorded by statistical tables and the actual intake of the population should be taken into account in order to avoid overestimation. In Austria, correction factors used to calculate corresponding amounts eaten by the population are also based on data from the early 1980ies originally collected for Switzerland [4]. Waste sorting analyses reflect the behaviour of householders properly for those items disposed into the waste bin but do not consider other types of disposal paths for food waste such as sewer, home composting or animals. Another means of estimating food losses is to use direct records from households where items purchased and amounts actually consumed are recorded in a diary. In this way, losses can be calculated. With this method however, underestimations may occur due to a conscious or unconscious impact of such an investigation on the participant. Thus, in line with specific situations, cases of 'undereating' (the study participant eats less than usual) or 'underreporting' (not the whole amount is reported) may occur. Moreover, the method is very time consuming, providing for evaluation of only a small sample [5]. The majority of results obtained in these studies will not be published with all information needed (e.g. only nutrition energy in kJ or kcal is provided), thus, adequate data pertaining to food losses may not be available.

Accordingly, the estimation of food losses in general, lost amounts relating to a specific section of the life cycle of food (e.g. processing, trading), as well as losses incurred for specific food product groups, is difficult. For life cycle assessment of food products this implies considerable uncertainties in calculation of the resource demand and environmental impact of food.

Few investigations and estimations have been described using properly applied methods, assumptions and conditions to investigate this problem. In addition to the scarcity of data there is also a lack of comparable units and bases for allocation, as illustrated by the following examples. In 1997 agricultural economists of the US Economic Research Service conducted a survey on food losses on the US market and concluded that approx. 27 % of the amount of food available for human consumption is lost during the stages of retail, food service and household [6]. In these cases, losses are further divided into several product groups whereas the highest percentage of losses was reported for fresh vegetables, fruit and milk. Estimations for Switzerland indicate a loss of food from production to the plate in the household ranging between 20 and 25 % [7]. In Germany it has been estimated that between 4 and 15 % of the net national production of vegetables and fruits, depending on the kind of vegetable or fruit, is lost on the way to the household [8]. A 10-week survey performed in Vienna revealed a loss of 45 kg of useable food products per day and retail shop of a food discounter [9]. Waste sorting analyses performed in Austria indicate that food disposed of in its original packaging or partly used accounts for 6 to 12 percent of residual household waste [10, 11].

Handling of food losses within LCA

In view of the lack of adequate data on food losses, the problem is mainly solved through application of personal assumptions or by ignoring the losses within the life cycle assessment. In the case of large losses, the ignoring of the problem implies the need for an increased food production in order to achieve a given amount of food consumption. Moreover, results for energy and resource demand are underestimated with a higher quantity of pollutants being emitted. The following paragraphs present three examples to illustrate how different authors dealt with the problem of food losses within their life cycle assessment studies.

The first example addresses the environmental impact of bread depending on different production methods [12]. In order to assess bread losses on household level, the authors questioned 41 people concerning their bread wasted at home. This restricted survey indicated how approx. 25 % of bread is lost in households. As there was no further possibility for the authors to verify their findings, they decided to exclude the losses from their calculations in order not to overestimate the latter. They concluded that losses should be carefully examined according to the aim of an LCA study in view of the important potential impact depending on kind of food [12].

One means of dealing with food losses at Swedish food service institutions within an LCA is provided by [13]. The authors studied four food service institutions (two schools, two restaurants) in Stockholm and concluded that in general 20 % of the food is lost. The amount of losses was determined by means of recordings made by restaurant staff in the case of storage losses and by weighing for other types of losses. The majority of losses occurred during the eating stage where 10 % of all food deliveries ended up as plate waste (see figure 1). In addition to the amount of food, also the category involved - 'meat and fish', 'potatoes, rice and pasta' and 'vegetables', was recorded by the study team. The categories wasted most frequently were 'potatoes, rice and pasta' in schools as well as 'vegetables' in the restaurants. The discarded food waste in investigated schools corresponded to an economic value of approx. 750 Euros per day. Restaurants could gain an additional 390 to 657 Euro by serving food losses instead of discarding them. To achieve an environmentally-appropriate result, the amount of arable land needed to produce food subsequently discarded was calculated by the authors. They found that the losses discarded in all Swedish food service institutions consumed 40,000 ha or 1.5 % of the total area cultivated in Sweden each year. Although meat contributes only 20 % of the losses, this category involves 91 % of the calculated cultivated area [13].

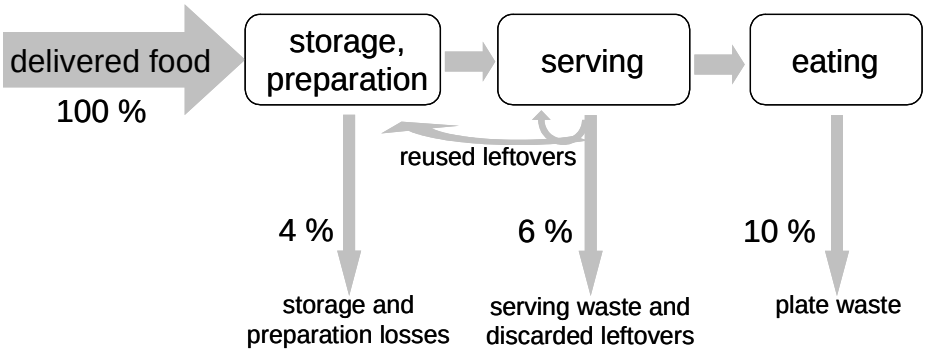

Figure 1: Average food losses in Swedish food service institutions, after [13]

The third example compares the ecological impact of three different diets: an average German diet, a diet with a high content of unprocessed food and a low content of meat and meat products as well as a vegetarian diet [1]. The data base refers to detailed eating diaries, thus it was necessary to convert the figures into purchased amounts in order to consider the overall environmental impact of the consumed amount. For each single item, the author used two correction factors, one for the correction of the weight changes during cooking, the second in evaluation of the losses due to preparation (peeling, cleaning) and spoilage of the food. The assumptions applied as correction factors were based on investigations published from 1988 to 1993. For bread and bakery products it was assumed that 2 to 11 % are lost due to preparation and spoilage from purchase to the table. The highest losses due to preparation and spoilage were observed for the food categories 'fish and sea food' with a maximum of 58 %, 'fruits' with 56 % and 'vegetables and pulses' with 53 % losses. Table 1 summarises the correction factors used for the main product groups.

Table 1: Correction factors for different food product groups used in [1]

	correction factor for cooking	correction factor for preparation & spoilage
bread, bakery products	1	0.89 - 0.98
grain products, nutriments	1 - 3	0.79 - 0.90
potatoes, potatoe products	0.97	0.79
vegetables, legumes	1 - 2.17	0.47 - 1
soja products	1 - 3	0.70
fruits, fruits products	1	0.44 - 0.99
nuts, seeds	1	0.54
milk, milk products	1	0.61 - 0.99
meat, meat products	0.68 - 1	0.69 - 0.98
fish, sea food	0.84 - 1	0.42 - 0.86
fat, oil	1	0.65 - 0.82
convenience products	1	0.8 - 0.85
spread (jam etc.)	1	0.98
sweeteners	1	0.90 - 0.95
sweets	1	0.92 - 0.98
beverages	1 - 66.67	0.75 - 0.99

Environmental impact of food waste in the waste management system

Besides ethical effects, food may constitute a nuisance in the waste management system depending on the type of treatment options used. During collection food waste results in bad smell (mainly meat) attracting insects. If food waste is collected separately and free from packaging, for example together with non-food organic waste such as garden waste, it can be converted into compost whereas the higher water content and lower portion of air needs more other material to structure the windrow. The easy availability of the organic matter of food waste promotes the formation of humic matter. Another option for application in the treatment of food waste is to use the energy for an anaerobic digestion process. Thus, biogas can be produced and the remaining residues used as fertilizer. The treatment of food waste in a mechanical-biological pretreatment facility leads to stabilization of the organic carbon content whereas nitrogen is stabilized to a lesser degree. Potential effects of nitrogen on the short and long term leachate composition require further investigation. Thermal treatment of food waste reduces the heating value of the waste due to the high water content. The least satisfactory waste management option is to dispose of food waste untreated in a landfill. Indeed, untreated landfilled food waste elicits methane emissions that contribute to the global greenhouse effect. An interesting field of investigation would be represented by the effect of landfilled food waste on different animals. Studies indicate that for the survival of specific domestic species, easy access to food from landfills is essential [14].

Conclusions

The bread production example illustrates the difficulties in estimating food loss for a specific food product. Although bread is a common foodstuff, it is difficult to obtain adequate figures for food losses – not only on household level. Thus, either greater efforts should be made to obtain reliable data or losses should not be taken into account, in spite of their considerable importance.

As indicated by the example from Sweden, it may be of importance to consider specific food losses in LCA although they may only contribute minimally to overall losses. Hence the losses of energy and resource intensive food categories such as meat, fish as well as vegetables and fruit grown under non-environmentally sound conditions or requiring transportation over long distances should be considered in LCA to provide a better estimation of consumed resources.

An estimation method for losses on household level was introduced by the third example from Germany. In this case, a detailed database for correction factors was used, unfortunately the reference date is obsolete and other similar data bases originating from the early 1980s have been identified [4].

In general, it should be reported how a surplus of food produced on European or national level or bought by a householder could be considered in an LCA. Is it really necessary to produce more food to provide adequate food supply, and should the amount of wasted food be considered within LCA? Is it essential to buy three yogurts when only one is eaten and the other two wasted, and should this be taken into account in calculations? On a national level it is clear that all produced food amounts should be included when calculating the environmental impact. But is this procedure correct when investigating a single product such as bread? Is a piece of bread 'responsible' for the additional unused amount of bread produced and perhaps also bought but not eaten? Meat is a particularly resource-consuming food product. As the example from Sweden indicates, 20 % of food losses in food service institutions alone account for 1.5 % of the Swedish agricultural area or 40,000 ha. Although meat contributes by only 20 % to the overall losses, it involves as much as 91 % of the calculated area. Although the agricultural reform has produced an undeniable effect on production, a problem remains with regard to the surplus of beef and other products originating within the European Community. Should the surpluses stored in huge warehouses, sometimes sold on the world market and sometimes merely discarded, also be taken into account on national level?

Finally, it should be kept in mind that food wasted in households is transported to the household, is stored in refrigerators and has to be collected and treated as waste without providing any benefit to the householder. Food discarded totally unused, such as products past their expiry date, is often disposed of together with the packaging. Thus, the packaging can not be recycled as it would be in case of separate collection.

The environmental impact of food pretreated adequately before final storage in landfill does not contribute to any important degree to the overall emissions manifested throughout the food cycle. It is however relevant that each additional ton of waste requiring collection, transportation and treatment is characterized by a demand for energy and increased capacity treatment facilities.

Different methods available for estimation of food losses along the life cycle have various advantages and disadvantages. However, the combination of methods is hindered by different units used and a lack of information concerning metadata. Thus, the consideration of food losses in life cycle approach remains complicated and implies considerable uncertainties in calculation of the resource demand and environmental impact of food.

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