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Review

Processing- and product-related causes for food waste and implications for the food supply chain

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ABSTRACT

Reducing food waste is one of the prominent goals in the current research, which has also been set by the United Nations to achieve a more sustainable world by 2030. Given that previous studies mainly examined causes for food waste generation related to consumers, e.g., expectations regarding quality or uncertainties about edibility, this review aims at providing an overview on losses in the food industry, as well as on natural mechanisms by which impeccable food items are converted into an undesired state. For this, scientific literature was reviewed based on a keyword search, and information not covered was gathered by conducting expert interviews with representatives from 13 German food processing companies. From the available literature, three main areas of food waste generation were identified and discussed: product deterioration and spoilage during logistical operations, by-products from food processing, and consumer perception of quality and safety. In addition, expert interviews revealed causes for food waste in the processing sector, which were categorised as follows: losses resulting from processing operations and quality assurance, and products not fulfilling quality demands from trade. The interviewees explained a number of strategies to minimise food losses, starting with alternative tradeways for second choice items, and ending with emergency power supplies to compensate for power blackouts. It became clear that the concepts are not universally applicable for each company, but the overview provided in the present study may support researchers in finding appropriate solutions for individual cases.

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1. Introduction

In 2011 the Food and Agriculture Organisation of the United Nations estimated that one third of the worldwide food production is wasted or gets lost on the way from farm to fork (FAO, 2011). Wasted food is associated with an unnecessary use of energy and water, and emissions of greenhouse gases generated by production and delivery operations (Papargyropoulou et al., 2014; Tiwari et al., 2014); it is also contradictory to the increased amount of food demanded by a growing population (Ehrlich and Harte, 2015; Godfray et al., 2010). Reducing food waste is therefore one of the goals the UN have set to achieve a more sustainable world by 2030 (United Nations, 2015).

In many cases it is processing that links agricultural materials to the consumer. It is therefore important to ensure processing efficiency, and to have sufficient information on factors which may induce or prevent food waste generation on the processing level. 39% of the food losses in the EU occur in food manufacturing, and 5% along the distribution chain (European Commission, 2011).

Suboptimal foods have recently been defined as edible foods perceived as undesirable by the consumer because of visual or sensory deviations, or uncertain safety (Aschemann-Witzel et al., 2015). Suboptimal foods frequently end up as food waste, i.e. "... any food, and inedible parts of food, removed from the food supply chain to be recovered or disposed" which is inaccessible for consumption (Fusions, 2014).

In line with this definition, food waste in the context of this review is considered as

- Any food-derived material lost during processing in the form of residues, faulty batches, retained or analysis samples, or by-products, and that is not recovered for human consumption. Such materials are frequently denoted as food or post-harvest losses because they are associated to food manufacturing and usually not wasted on purpose (Parfitt et al., 2010; Russ and Schnappinger, 2007); and
- Foods that are rejected and finally discarded at retail or household levels because they do not match consumer expectations or legal requirements regarding quality or safety. This type of food waste is mainly connected to the consumer who decides what to purchase and consume, but also involves other actors (farmers, processors, carriers) who are responsible for the quality in which the food is delivered to the consumer (Aschemann-Witzel et al., 2015; Salhofer et al., 2008), and includes food that undergoes microbiological spoilage or mechanical damages during delivery, forcing the retailer to eventually reject it.

After providing a general overview on food wasted in the supply chain with a specific focus on logistical issues (chapter 3), this work aims to discuss

- Processing techniques and requirements of quality assurance in the food industry that limit an efficient and sustainable resource exploitation (chapter 4), and
- Physical, chemical, and biological mechanisms by which impeccable food items are converted into suboptimal foods (chapter 5).

The paper provides a unique overview of processing- and product-related causes of food waste, and contributes to tackling the food waste issue by identifying potential actions of food supply chain actors.

2. Data retrieval

2.1. Literature search

A literature search was carried out using scientific databases (Web of Science, Business Source Complete, EBSCO, SciFinder, Science Direct, PubMed, and Google Scholar) and the book catalogue of the Staats- und Universitätsbibliothek Dresden (Germany). A general overview on the topic was obtained by searching for pre-defined keywords, namely "food waste" and "food loss" in combination with "food industry", "food manufacturing", or "food processing". "Consumer" and "household" level food waste, as well as non-food utilisation of food waste (e.g., "biogas", "bioethanol", or "animal feed"), and the processing of "waste water" were explicitly excluded from the search. Studies and reports published in English from 2005 to 2016 were considered, and an excessive forward-backward search without limitation was subsequently performed.

Furthermore, two specific topics were selected for profound discussions, namely:

- Foods that are suboptimal because of sensory deviations or because of ambiguous date labelling. Information was achieved by searching for reviews on prevalent defects, namely "fruit enzymatic browning", "bread staling", "chocolate fat bloom", and "food lipid oxidation", followed by a forward-backward search to identify other causes of quality losses. The search on date labelling alternatives was conducted similarly using "intelligent packaging" and "indicator technology", and targeted on reviews and recent research papers; and
- Causes of significant food waste in the processing sector. Except for possibilities to valorise food processing by-products, literature on food waste in the processing sector is scarce. By-product valorisation strategies are briefly reviewed on the basis of information from books, recent reviews, and communications obtained during literature search. Supporting database searches were performed using "by-products" in combination with "food processing" or "food industry".

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