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Food waste reduction in supermarkets – Net costs and benefits of reduced storage temperature

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ABSTRACT

Food waste is a major problem and therefore measures are needed to reduce it. Since expired best-before date is a frequently cited cause of food waste in supermarkets, prolonging shelf life could reduce food waste. Longer shelf life could be achieved in different ways, e.g. reduced storage temperature. However, there is limited knowledge regarding the extent to which longer shelf life actually leads to reduced food waste, and whether the benefits of reduced waste exceed the increased energy costs of maintaining reduced storage temperature. Therefore this study calculated the net effect of reducing food waste in supermarkets by reducing the storage temperature through simulating the relationships between food waste reduction, longer shelf life, reduced storage temperature and increased energy costs.

A case study was performed using three years of data on cheese, dairy, deli and meat product waste in six Swedish supermarkets, together with published data on microbiological growth at different temperatures and on the energy requirement for cold storage at different temperatures. Food waste was found to be reduced with lower storage temperature for all food products tested. This measure gave increasing net savings in terms of money and greenhouse gas emissions for meat products with decreasing storage temperature. Deli products had net savings close to zero, while for dairy and cheese products there were net losses, since the costs of reducing storage temperature exceeded the potential savings. Therefore, reducing storage temperature has the potential to reduce waste, but at a total net cost. However, a net benefit can be achieved if the measure is only introduced for products with high relative waste, low turnover and high value per unit mass.

1. Introduction

Rough estimates by the Food and Agricultural Organization of the United Nations show that one-third of the food produced worldwide is wasted along the supply chain (Gustavsson et al., 2011). Apart from the moral issue of throwing away edible food items when people elsewhere are starving (Stuart, 2009), this is also associated with unnecessary use of natural resources (Nellemann et al., 2009) and loss of monetary value (Ventour, 2008). This loss of food is a problem along the whole food supply chain, but since more value in terms of money and resources is added for every step in the food supply chain, waste is more costly as the chain progresses. If food is wasted at the end of the supply chain, more sub-processes will have been in vain and the losses will therefore be larger than if the same food had been wasted at the beginning of the process (Eriksson and Strid, 2013).

Supermarkets are located close to the end of the supply chain and collect large quantities of food in a limited number of physical locations. Therefore they are potentially good targets for waste-reducing measures, although they only contribute a small share of waste in comparison with other stages of the food supply chain (Jensen et al., 2011; Göbel et al., 2012). Recent studies of food wastage in supermarkets have mostly focused on describing the quantity of waste, its causes and how it could be given to charity in order to avoid wastage (e.g. Alexander and Smaje, 2008; Lee and Willis, 2010; Gustavsson and Stage, 2011). One of the problems causing food wastage is short shelf life of perishable food items (Mena et al., 2011), which makes forecasting and ordering more difficult since fluctuating demand has to be predicted. A slump in demand can cause a low sell rate or low turnover, which may result in higher percentage waste (Hanssen and Schakenda, 2011; Eriksson et al., 2014). Since turnover also has an influence on shelf life (the time between packaging and best-before date), it can influence percentage waste, as it determines the time available for supermarkets to sell the products. A possible cause of waste is when too many items of each product are ordered, so that not all can

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be sold before the best-before date (Eriksson et al., 2014). Therefore the minimum order size may be important for the amount of waste. This minimum order size is often set by the wholesale pack size, i.e. the size of wholesale box in which products are packed for delivery to supermarkets. According to Eriksson (2012), there is a greater risk of products being wasted when the turnover is low, the shelf-life short and the minimum order size large. However, Eriksson et al. (2014) concluded that the influence of these three parameters is not equally strong and thus there is a need to establish their relative influence in order to adjust shelf life or minimum order size to compensate for lack of turnover and thereby reduce food waste in supermarkets. According to Björkman (2015), shelf life is the parameter with the greatest influence over waste of individual articles and should therefore be targeted for the most efficient waste-reducing measures. This is in line with the suggestion by Eriksson and Strid (2013) that minced meat products with low turnover could be sold frozen instead of chilled in order to reduce food waste.

Of the perishable foods wasted in supermarkets, bread and fresh fruit and vegetables are often described as the product groups with the greatest wasted mass (Lebersorger and Schneider, 2014). However, when the carbon footprint is considered, animal products such as meat, deli, dairy and cheese increase in importance (Scholz et al., 2015) and should be considered hotspots for waste-reducing measures. According to Eriksson (2012), the wasted mass in relation to the sum of wasted mass and sold mass is 0.53–0.60% for cheese, 0.33–0.35% for dairy, 1.4–1.8% for deli and 1.2–1.5% for meat. The relative waste of cheese, dairy, deli and meat products can therefore be considered low, reflecting measures that have already been taken. However, there is still room for improvement, especially since Eriksson et al. (2015) found that all waste management options they investigated, including anaerobic digestion and donations, only marginally provided savings by reducing the carbon footprint of the food produced in vain.

To prolong the shelf life of perishable foodstuffs, traditional preservation methods such as drying, curing and pickling cannot be used, since they change the taste and texture of food so that it can no longer be categorised as fresh. Instead, other methods that preserve the freshness, e.g. including additives, improving packaging and lowering the storage temperature, can be used. In Sweden, a campaign with the message "reduced storage temperature (from 8 °C to 4–5 °C) in the whole food supply chain" was launched in 2011 by the Stockholm Consumer Cooperative Society (2011a, 2011b). As a result, the Swedish Environmental Protection Agency (SEPA) carried out an investigation to determine the possible consequences of reduced storage temperature (Jensen et al., 2013). It was found that lower storage temperature was welcomed by a number of company representatives interviewed, but the costs of reducing storage temperature and the effect this measure could have on food waste were not determined.

Prolongation of shelf life could be achieved in several different ways. Since it is always the producers that set the dates based on their own standards, experience and tests (Jonsson, 2012), it is a quite flexible system that can adapt to new circumstances, e.g. lower storage temperature. The shelf life in Sweden is limited by either a best-before date that only reflects product quality or a use-by date that reflects product safety and is therefore only used for a few of the most perishable products with a high microbial risk, e.g. minced meat (National Food Agiency of Sweden, 2004). In practice, no products with expired date labels are sold in Sweden since customers will not buy them, even though it is only the use-by date that refers to legal restrictions on selling products with expired date labels. A reduction in storage temperature will decrease the growth rate of both pathogens and product spoilage organisms and therefore the shelf life can be extended regardless of the type of date label. However, a prerequisite for achieving reduced storage temperature is for producers to adjust their products with a longer shelf life and new storage conditions and for retailers to agree to buy these products and store them suitably.

There is a general lack of data on the ability of food waste prevention measures, including reduced storage temperature, to reduce food waste. Among the few previous studies examining waste prevention measures in supermarkets, two (Salhofer et al., 2008; Schneider, 2013) actually investigated donation to charities, which according to Papargyropoulou et al. (2014) is a separate issue and less favourable than actual prevention. True prevention, where the inflow of food is reduced, is described by Gentil et al. (2011) as a measure that reduces waste by reducing food production. The problem with that study is that it simply assumed a reduction of 20% and did not specify how this reduction could be achieved.

The objective of the present study was therefore to theoretically evaluate the potential cost and potential savings in food waste in supermarkets on reducing storage temperature in the food supply chain. This was done by examining the relationships between: shelf life and food waste, storage temperature and shelf life, and storage temperature and energy consumption. The overall aim of the study was to provide better data on measures to prevent food waste in supermarkets and thereby reduce the financial losses and the greenhouse gas emissions.

2. Materials and methods

The data were collected in six supermarkets (belonging to the Willy:s retail chain) during three years, 2010–2012, as part of the normal waste recording routine (Eriksson, 2012). This routine was not introduced by the researchers but used in order to collect data. The routine starts with an inventory in the morning where products considered unsellable, e.g. with an expired best-before or use-by date, are removed and recorded using the European Article Number code on the packaging. Products from the dairy, cheese, deli and meat departments were selected for the present analysis because they are all sold as packed goods with a label including a best-before date or use-by date, and because they all have a comparatively short shelf life. The data recorded include pre-store waste and in-store waste (Eriksson et al., 2012), but in this study only the in-store waste data were included since pre-store waste is caused by rejects and not by expired shelf life. Every wasted food product was valued as the cost (excluding value-added tax) to the store of purchasing it during the week in which it was wasted. To calculate the total carbon footprint of each product, the number of items wasted was multiplied by the mass of each product and a carbon footprint value for each product taken from Scholz et al. (2015) and Scholz (2013). Those studies used life cycle assessment (LCA) and a literature review to produce these values for the same stores and products as analysed in this paper. The carbon footprint (CF) was used synonymously with GWP_{100}, where emissions of CO_2, N_2O and CH_4 were included. The CF of N_2O and CH_4 was expressed relative to CO_2 according to the IPCC values (Solomon et al., 2007) and expressed in terms of carbon dioxide equivalents (CO_2e). The CF of each product encompassed cradle to retail emissions, including production and transport from the country of origin to the city of Stockholm, Sweden. The data did not include packaging, cold storage or waste, due to insufficient data sources.

Data on shelf life and wholesale pack size provided by the supplying company (DAGAB) were paired with the products in the list of wasted items. For these items, the wholesale pack size equals the minimum order size, i.e. the minimum number of products a supermarket can order in one purchase. The shelf life describes the time from packing date to best-before date or use-by date.

This study was performed as a three-step process in which: (1) the potential to prolong shelf life at different storage temperatures