**Waste Reduction in Fresh Food Supply Chains**

**Abstract.** The paper studies a well-known phenomenon, information sharing in supply chains, in a new context, fresh foods, with a specific goal, supporting sustainable performance in the supply chain. Fresh foods are important for retail stores, representing around half of retail sales, but form a challenging and heterogeneous group of products to manage. The value of the paper lies in its pointing out detailed solutions to how in real-life supply chains data can be used efficiently to improve the performance of the supply chain.

 **Keywords.** Fresh food, perishables, supply chain, waste reduction, supply chain, case study.

# 1 Introduction

Sustainable performance has become an important target in perishable food supply chain management. The average loss over the whole chain from production to the retail shelf and the consumer’s fridge is estimated to be 35% (Scheer, 2006), or, on the basis of a literature review, between 20 and 50% of the quantities produced (Koivupuro et al., 2010). A Swedish study reported that in retail stores, the wastage of perishable food was 4% and at wholesalers 3.30% of total sales (Andersson et al., 2010). Ensuring that the product reaches the end consumer in full quantity and in perfect condition is of crucial importance for increasing sustainability (Nereng et al., 2009). The causes of the high quantity of unsold products at retail stores *(products exceeding their shelf life)* include ordering more than the real demand or that products reach the store shelf too late and with a short remaining shelf life (Mena et al., 2010). The root causes leading to these effects have been identified as a lack of information sharing, forecasting difficulties and poor ordering, and problems in promotions management.

In managing fresh food supply chains, the specific characteristics of the products set requirements for speedy and accurate operations. The challenges of the fresh food supply chain include, in addition to the very short product shelf life, the heterogeneous nature of the whole fresh food group and the physical requirements for handling and storage. These features set high requirements for supply chain management and planning to achieve the goal of ensuring availability in retail stores without increasing the quantity of wasted products in different supply chain phases. Waste reduction has become an important goal in order to implement sustainable performance in fresh food supply chains.

The efficiency and performance of the whole supply chain is essential in minimizing the environmental effects. Thus, producing only the volumes that have been demanded can significantly reduce the waste caused in perishable food supply chains. This elicits the question of the location of the order penetration point (OPP) in the chain, and how much the producer makes to order, and how much to stock based on forecasts (Van Donk, 2001). Past research and company practices have mainly focused on separate segments of the supply chain, for example farmers and growers, retailers, transport and distribution, or processing and manufacturing (Smith, 2008, Mena et al., 2010). The purpose of this paper is to demonstrate how to benefit from sharing demand data and shelf life data to achieve sustainable performance of fresh food supply chains. The research question is how shared information needs to be utilised in order to create a sustainable fresh food supply chain.

# 2 Literature Review

## 2.1 Fresh food supply chain characteristics

The management and performance of supply chains for perishable food products are significantly affected by the specific features of fresh food, as well as current trends in this very competitive industry. We study here three key characteristics of the food product market that affect food supply chains: demand uncertainty, customer order lead-time and supply chain lead time allowance (Kittipanya-ngam et al., 2010).

Because of their short lifetime, perishable products require a short supply chain lead time allowance (SCLT). This means minimizing the total time that it takes for the product to go through the supply chain. In addition, the customers in this market require short customer order lead times (COLT), i.e. rapid replenishment (Kittipanya-ngam et al., 2010). These two characteristics, SCLT and COLT, thus require high responsiveness on the part of the supply chain management. The third characteristic, demand uncertainty, incorporates the degree of product variety, the frequency/degree of new product development, and the stage of the product life cycle. Consumers’ wishes seem to change at an ever-growing rate, causing an increase in packaging sizes, the number of products, and the number of new products introduced (van Donk, 2001). In addition, Taylor and Fearne (2009) find that variability in consumer demand does not only depend on natural causes such as seasonality and weather, but is more induced by promotional activities. Thus, increased demand uncertainty will require greater supply chain flexibility, instead of economies of scale. These speed and flexibility requirements are in line with the waste reduction objectives.

In order to manage the requirements for speed and flexibility, different supply chain parties need to have at least inter-firm collaboration at an operational level and unified supply chain support systems (Kittipanya-ngam et al., 2010). However, this is a challenge for the companies along the supply chain. Organisations that are not open to sharing data or lack leading forecasting techniques have been identified as root causes of food waste between suppliers and retailers (Mena et al., 2010; Taylor and Fearne, 2009). In addition, performance indicators have been identified as one of the root causes of waste since they were focusing on cost, efficiency, and availability. In particular, it has been observed that availability is accorded greater importance than waste.

## 2.2 Information sharing in supply chains

Supply chain literature offers solutions on how to benefit from shared information (Aviv, 2001, Cachon and Fisher, 2000, Chen, 1998, Fliedner, 2003, Gavirneni et al., 1999, Lee et al., 2000, Li et al., 2000, Zhao et al., 2002, Zhoua and Benton, 2007). In the context of fresh foods, a limited number of writers consider the topic (Ketzenberg and Ferguson, 2005, Taylor and Fearne, 2009). The availability of data is no longer a problem, but the challenge still remains of how to best utilise the data to improve the performance of the chain.

In his study, Fliedner (2003) examined several trade journals and reports and came up with a list of benefits resulting from sharing information. Both the retailer and manufacturer can expect to benefit from increased sales, lower product inventories, higher service levels or order fill rates, improved forecast accuracy, and lower system expenses. Other suggested benefits include reduced capacity requirements, faster order response times and faster cycle times, and a reduced number of stocking points, i.e. direct material flows.

In their study Cachon and Fisher (2000) showed that supply chain costs are 2.2% lower on average with fully shared information and that the maximum difference is 12.1% of total supply chain costs. Similarly, Chen (1998) found that centralised information lowers supply chain costs by 0-9% and on average by 1.8%. Aviv (2001) showed that employing forecasting collaboration in a two-echelon supply chain results in an average cost reduction of 10% in the supply chain. He also found that the value of collaboration increases when lead times in the supply chain decrease.

In cases where the demand is highly and positively correlated or highly variable or when the lead time from the manufacturer to the retailer is long, information sharing results in inventory reduction, especially for the manufacturer (Lee et al., 2000). Furthermore, they also found that information sharing enables the manufacturer to reduce his expected inventory holding and shortage costs.

# 3 Used Methodology

The goal in this paper is to study how shared information can be utilised to improve shelf availability, reduce waste, and improve production planning. The study is an exploratory case study in three fresh food supply chains in the Nordic countries. This method was selected for two reasons. First, the phenomenon seems to be new, and in the mapping stage, and therefore suitable for a case study, as case studies offer a means to explain and explore new phenomena (Handfield and Melnyk, 1998, Eisenhardt, 1989) and offer a means for studying complex real-life events (Yin, 2009). In case studies, the variables can be identified and patterns between variables can be observed (Eisenhardt, 1989), and this capability supports the purposes of our study: to understand the dynamics between planning and information-sharing practices and supply chain performance.

The cases are real-life cases where the authors of this paper have acted as developers or advisors. The cases were selected to represent solutions where the sophisticated use of shared information is realised or suggested. Another reason for selecting these cases was the challenging type of products; we wanted to discover if real-time information sharing can offer benefits for products with a very short shelf life. All the cases focus on products with a shelf life of only a few days. The unit of analysis is the supply chain. All the data used are real-life implementation data from the case companies. The data were collected by taking part in development activities which allowed the authors to get access to company databases. In addition, interviews were carried out.

All the cases were analysed separately, and then a cross-case analysis was carried out, as suggested in the literature (Eisenhardt, 1989). In cases 1 and 2 a manual follow-up of shelf availability, product age, delivery accuracy and wasted products (due to ageing) was implemented. A special study concerned the impact of holidays on these measures. The purpose of the cross-case analysis was to identify which improvement measures were utilised to change the performance of the supply chain. Therefore the cross-case analysis studied using shelf life and demand information, improving the forecasting process in the chain, physical changes in the supply chain, and how the time schedule was changed.

# 4 Case Studies

Here the cases are described first separately and in Table 1 some background information on the cases is offered. The changes implemented in each case are collected in Table 2 as well as descriptions of the improvements that were achieved.

Table 1. Description of the cases.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Case** | **No. of products****studied** | **Product shelf life** | **Time period studied** | **Main problems in the supply chain** |
| 1 Milk | 10 products in pilot project | 7 days | 10 weeks, ongoing | Slow response to changes in demand, high inventories in stores to ensure availability, inaccurate ordering causing high bullwhip effect |
| 2 Fish | Over 10 | 5-30 days | 10 weeks, ongoing | Lots of wasted products or out-of-stocks at the retailer |
| 3 Poultry | 1 product  | 11 days | 1 month | No shelf life management, products reach the store with short remaining shelf life |

Case 1: Fresh Milk

The first case represents a supply chain of perishable milk products with a shelf life of 7 days. In the initial situation, the operations were based on orders: the retailer placed an order with the wholesaler, who combined all the retailer orders and placed a summary order with the producer. The producer used a make-to-stock order fulfilment strategy and the products were transported through the wholesaler to the retailer. To reduce the significant bullwhip effect in the supply chain, a few changes were made. Instead of combining retailers’ orders, the wholesaler adopted a sophisticated forecast method to base orders on. Additionally, the wholesaler moved the stock of finished goods to 15 cross-docking terminals across the country in order to allow order-picking as close to the end customer as possible. This allowed more ordering time for the retailer and fast deliveries.

By means of this arrangement the retailer was able to see the actual sales during the daily peak hours, and more importantly, at weekends, before placing the order. The change resulted in a significant reduction in the bullwhip effect, improved shelf availability for 7 of the studied 10 products, and reduction in food waste as well. The waste reduction was for some products over 20 percent units, and in general waste was reduced for 9 products out of 10.

Case 2: Fish Products

The second case represents a supply chain of packed fish products with a shelf life varying from 5 to 30 days. Compared to the retailer and the wholesaler, the producer is rather small and volumes are small as well. The former order-based replenishment system caused very high product waste at the retailer who, in placing orders, had to find a balance between empty shelves (too low a quantity ordered) and causing high waste (too high a quantity ordered). On the basis of retailer orders, the producer used a make-to-stock order fulfilment strategy based on their own forecast. Physical products were transported from the producer’s stock to the 3PL operator and distributed from there to the wholesaler, who combined products with other products and distributed those to the retailer. A new forecasting method was applied. The wholesaler places a forecast order with the producer, who delivers products straight from production to the wholesaler. This leads to the benefit that the retailer is able to place an order significantly later. As a result of this arrangement product availability at the store improved remarkably, and product waste has fallen by 57%.

Case 3: Fresh poultry

The third case study is concerned with improved shelf life management of fresh poultry products through a supply chain with four parties: the poultry processor, the wholesaler (dealing only with information flow between retailers and the processor), a logistics company (dealing with the material flow between the processor and retailer), and the retailer. The products have 11 days of shelf life from the slaughtering of the chicken to the consumer. In the chain, there were several ways to manage the short remaining shelf life at different points in the supply chain. The processor is able to repack and freeze the products, thus enhancing their shelf life, but causing additional costs. Additionally, the retailer can refine the products in their own cooking facilities, which also adds costs. In each phase, price discounts are used if the products’ shelf life is lower than expected, which reduces profit margins. At the retailer the remaining products are wasted if the retailer does not have cooking facilities.

The analyses revealed several issues in shelf life management. The remaining shelf life at the point of arrival at the logistics company was expected to be 9 days, but was remarkably less for half of the batches. The greatest variability in the shelf life is caused at the poultry processor, where the products were kept in stock even for four days before being shipped. A lower demand at the beginning of the week relative to the end of the week, as well as the fact that the processor does not produce during the weekend, has caused the processor to operate according to the make to stock (MTS) strategy. Only one of the parties, the logistics company, has the data on products’ shelf life in their IT system. In the current state of the supply chain there is a lack of chain-wide understanding of what actually takes place regarding products’ shelf life. An analysis of the value-adding (VA) and non-value-adding (NVA) times revealed that the NVA times can, in the best case, account for as little as 6.8% of the total shelf life, and this is the case in about one out of the four batches studied. In one out of three batches, NVA times account for about 42.5% of the total shelf life. The display time at the retailer is considered as necessary but non-value-adding.

First, it is proposed that the shelf life data need to be included in the planning and control systems, as well as being considered as a performance indicator for different parties in the supply chain, for example by adopting barcodes that include shelf life data. Second, several changes in the order practice of the retailer are proposed. Sharing point of sale -data (PoS) from each shop directly with the processor could enable accurate demand forecasting to take place. Earlier orders from retailers allow make-to-order production at the processor, instead of relying on their forecast. Third, the intermediate storage and packaging by the logistics company could be left out if orders for individual retailers are packed at the processor and sent directly to the retailers. This can end up with about 24 hours of shelf life being gained.

Table 2. Implemented changes and their impact in different supply chain phases.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Case** | **Order patterns** | **Material flow**  | **Forecasting and planning process** | **Improvements achieved** |
| 1 Milk | Retailer is able to place orders significantly later | OPP is moved as close to the retailer as possible. Customer order-picking takes place closer to the end customer. | Material flow is based on accurate forecast from producer.  | Significant reduction in bullwhip effect, somewhat better shelf availability, and reduction in food waste. Time between actual order and delivery is 5 hours at the shortest. |
| 2 Fish | Retailer is able to place orders significantly later | Logistics company left out of the process. Customer order-picking takes place closer to the end customer. | Wholesaler places a forecast order to manufacturer. | Product availability at the store has improved dramatically, and product waste has fallen by 57%. |
| 3 Poultry | Getting orders for slaughter 5 hours earlier. | Logistics company left out of the process.  | Early orders enable more accurate slaughtering and MTO production. | Estimated benefits: Better follow-up of products and faster material flow, products at the retailer 1 to 3 days fresher.  |

# 6 Discussion and Conclusions

Our study is based on the assumption that reducing the waste of a product and ensuring that the product reaches the end consumer in perfect order will increase the sustainable performance of the supply chain (Nereng et al., 2009). The purpose of the study was to explore how information sharing can benefit the performance of fresh food supply chains, particularly for products with a very short shelf life.

The cases results provide evidence on the benefits of information sharing in perishable food supply chains. First, our study points out the exact uses of demand information in perishable food supply chains and detailed analysis of the benefits. Second, the study identifies problems in managing shelf life data in various supply chain phases. Third, this study offers new measured effects of improved visibility on the supply chain performance, particularly in terms of shelf availability and waste.

In our cases the benefits in actual production remain low since producers have only limited opportunities to utilise shared demand data. The main benefits from the improvements can be seen at the retail store level. However, the changes that were taken mainly concerned the upper parts of the chain. Improving the supply chain requires changes in the whole supply chain, not only in the phase where the problems occur or benefits are realised. This, however, raises questions about sharing the benefits and costs between the parties involved in the supply chain.

There was an interesting observation in connection with the location of the order penetration point, OPP, in fresh food supply chains: initial findings indicate that the OPP should be moved as close to the retail customer as possible. This means that the producer operates based on forecasts, which is a contribution to Van Donk’s study (2001). This finding emphasises the role of an efficient forecasting process because a larger share of the chain operates on the basis of forecasts. On the other hand, order-driven operations at the producer were found beneficial, in particular in defining incoming raw material quantities. This topic requires further research.

We conclude that the design of a supply chain needs to serve specific features of perishable products to achieve a sustainable supply chain. It was found out that synchronising information and material flow is essential when improving the performance of the supply chain. Fine-tuning the daily and weekly demand pattern in combination with the capacity at the processor has a remarkable effect on the responsiveness of the supply chain.

The case study method was used for studying the phenomenon of improving sustainable performance in fresh food supply chains. The study does have limitations and left many questions unanswered. The findings are based on three Nordic supply chains, which were studied in depth. Not all the findings can be generalised. One question not covered in this research is how to measure sustainable performance. The measurement should cover two contradictory goals: improving shelf availability and minimising waste.

**References**

 Andersson, E., Köhlenstrand, M., Lindqvist, M., Mellgren, E. and Rydmark, H., (2010). *Maten som försvann - En studie om färskvarukassation inom Coop*. Uppsala 21.1.2010. Available at: [www.konsumentforeningenstockholm.se](http://www.konsumentforeningenstockholm.se/upload/Konsumentfr%C3%A5gor/Maten%20som%20f%C3%B6rsvann_KfS_slutversion_light.pdf). In Swedish.

Aviv, Y., (2001). “The effect of collaborative forecasting on supply chain performance”, *Management Science*, Vol. 47, No.10, pp. 1326-1343.

Barratt, M., Choi, T.Y. and Li, M., (2011). “Qualitative case studies in operations management: Trends, research outcomes, and future research implications”, *Journal of Operations Management*, Vol. 29, Iss. 4, pp. 329-342.

Cachon G.P. and Fisher, M. (2000). “Supply chain inventory management and the value of shared information”, *Management Science*, Vol. 46, Iss. 8, pp. 1032-1048.

Chen, F. (1998). “Echelon reorder points, installation reorder points, and the value of

centralized demand information”, *Management Science*, Vol. 44, No. 12, pp. S221-S234.

Eisenhardt, K. M. (1989). “Building Theories from Case Study Research”, *The Academy of Management Review,* Vol. 14 No. 4**,** pp. 532-550.

Ferguson, M. and Ketzenberg, M., (2006). “Information sharing to improve retail product freshness of perishables”, *Production & Operations Management,* Vol. 15, No. 1, pp. 57-73.

Fliedner, G., (2003). “CPFR: an emerging supply chain tool”, *Industrial Management & Data Systems*, Vol. 103, No. 1, pp. 14-21.

Gavirneni, S., Kapuscinski, R. and Tayur S., (1999). “Value of information in capacitated supply chains”, *Management Science*, Vol. 45, Iss. 1, pp. 16-24.

 Handfield, R. B. and Melnyk, S. A., (1998). “The scientific theory-building process: a primer using the case of TQM”, *Journal of Operations Management,* Vol. 16 No. 4**,** pp. 321-339.

Kittipanya-ngam P, Shi Y. and Gregory M.J., (2010). “Food supply chain (FSC) in manufacturing companies – An exploratory study on product and configuration”, in *Proceedings of 17th EurOMA Conference,* Porto, Portugal.

Koivupuro, H-K., Jalkanen, L., Katajajuuri, J-M., Reinikainen, A. and Silvennoinen, K., (2010). *Food waste in the supply chain, Literature review*. MTT Report 12. Available at http://www.mtt .fi/ mttraportti/pdf/mttraportti12.pdf. In Finnish.

Lee, H.L., So, S.C. and Tang, C.S., (2000). “The value of information sharing in a two-level supply chain”, *Management Science,* Vol. 46, Iss. 5, pp. 626-643.

Li, G., Lin, Y., Wang, S.Y. and Yan, H., (2006). “Enhancing agility by timely sharing of supply information”, *Supply Chain Management – An International Journal*, Vol. 11, Iss. 5, pp. 425-435.

Mena, C., Adenso-Diazb, B. and Yurtc, O., (2010). “The causes of food waste in the supplier-retailer interface: Evidences from the UK and Spain”, *Resources, Conservation and Recycling*, doi:10.1016/j.resconrec.2010.09.006

Nereng, G., Semini, M., Romsdal, A, and Brekke, A., (2009). “Can innovations in the supply chain lead to reduction of GHG emissions from food products? A framework”, Conference: *Joint Actions on Climate Change*, Ålborg, Denmark.

Scheer, P-P., (2006). “Optimizing supply chains using traceability systems”, *Improving Traceability in Food Processing and Distribution*, Cambridge, England: Woodhead Publishing Limited, pp. 52-64.

Smith B.G., (2008). “Developing sustainable food supply chains”, *Philosophical Transactions of the Royal Society B*, 363: pp. 849-861

Taylor, D.H. and Fearne, A., (2009). “Demand management in fresh food value chains: a framework for analysis and improvement”, *Supply Chain Management,* Vol. 14, No. 5, pp. 379-392.

Van Donk, P., (2001). “Make to stock or make to order: The decoupling point in the food processing industries”, *International Journal of Production Economics*, Vol. 69, pp. 297-306.

Voss, C., Tsikritsis, N. and Frohlich, M., (2002). “Case research in operations”, *International Journal of Operations & Production Management,* Vol. 22 No. 2**,** pp. 195-219.

Yin, R. K., (2009). *Case Study Research: Design & Methods*, SAGE Publications, Thousand Oaks.

Zhao X., Xie J. and Zhang W. J., (2002). “The impact of information sharing and ordering co-ordination on supply chain performance”, *Supply Chain Management*, Vol.7, Iss. 1, pp. 24-40.

Zhoua, H. and Benton, W.C. Jr,, (2007). “Supply chain practice and information sharing”, *Journal of Operations Management*, Vol. 25, Iss. 6, pp. 1348-1365.