Linkage Between Delivery Frequency and Food Waste: Multiple Case Studies of a Norwegian Retail Chain

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Lukas Chabada[1], Heidi Carin Dreyer[1], Hans Henrik Hvolby[2, 1], Kasper Kiil[1]

[1] Norwegian University of Science and Technology, Department of Production and Quality Engineering, Trondheim, Norway
lukas.chabada@ntnu.no, heidi.c.dreyer@ntnu.no, kasper.kiil@ntnu.no
[2] Aalborg University, Centre for Logistics, Department of Mechanical and Manufacturing Engineering, Aalborg, Denmark
hhh@celog.dk

Abstract. The main objective of this paper is to investigate linkage between delivery frequency and food waste of chilled products by testing the hypothesis – the higher the delivery frequency, the lower the food waste. Multiple case studies have been used to test the hypothesis. Food waste ratios of five product groups have been compared in three delivery frequency scenarios, namely low delivery frequency , medium delivery frequency and high delivery frequency scenario. Moreover, food waste ratios of different product groups have been compared to each other within each delivery frequency scenario. The findings show a strong negative correlation between delivery frequency and the food waste ratio for each investigated product group, which supports the hypothesis. On the other hand, food waste ratios among different product groups within the same delivery frequency scenarios vary significantly.

Keywords: food waste, delivery frequency, retail, logistics, chilled products

1 Introduction

There are substantial levels of food waste at retail stage of the food supply chain in Nordic countries, as uncovered by recent studies, especially for fresh and chilled product groups [1-3]. Reduction of such food waste has, therefore, got an increased attention from research community, as well as practitioners in retail chains.

Studies by Mena, Adenso-Diaz [4], Mena, Terry [5], Beretta, Stoessel [6], Darlington, Staikos [7], Taylor [8] or Kaipia, Dukovska-Popovska [9] have presented various causes of food waste where several were related to logistics and supply chain processes, such as long lead times, low delivery frequencies, high inventories and safety stocks, inaccurate forecasting or inefficient order management. However, there is still a limited number of studies investigating the causes and collecting the empirical evidence on linkages to food waste, or comparing their relative impact on food waste. Such studies are necessary in order to become effective and efficient in identifying and minimising food waste.

Among the afore-mentioned causes, the linkage between delivery frequency and food waste has been partly investigated by van der Vorst, Beulens [10]. Delivery frequency can be defined as the number of deliveries per certain period of time. In their study, delivery frequency is defined as the number of deliveries per week [10]. They simulated scenarios with different delivery frequencies per week for chilled salad and observed how throughput time and inventory levels change. Their simulation indicates that the higher the delivery frequency the lower the throughput time and inventory levels, impelling higher product freshness, which could be interpreted as less food waste. The limitations of the simulation approach are that it usually considers only a few factors what can significantly modify the findings from the real life situation. Based on their indications, we therefore decided to test the hypothesis:

"The higher the delivery frequency, the lower the food waste."

The hypothesis is tested by investigating the linkage between delivery frequency and food waste in practice by using data from 4 stores. Moreover, different product groups have been considered in order to see whether the hypothesis is valid for several product groups, and what the potential deviations are between the groups.

The reminder of the paper describes the data collected in the case companies and methods used for data collection and analysis. Further, the description of cases and findings are presented and discussed in terms of the hypothesis. Finally, concluding propositions and topics for further research are highlighted at the end of the paper.

2 Methods for data collection and analysis

The purpose of the study is to provide empirical evidence about linkage between delivery frequency and food waste, as formulated in the hypothesis. Multiple case studies have been selected as one of the methods recommended by Yin [11] for testing hypotheses. The advantage of using case research is in its ability to investigate a research problem within the complexity of real-life [12], thus testing the hypothesis against empirical data [13].

The case study protocol has been developed for collecting and analysing the data across the case companies. Data on sales, food waste and delivery frequencies per different product groups has been collected in four Norwegian stores. The main sources of data were interviews, point-of-sales data and insights to internal documents of terms and conditions between the wholesaler and stores. Data on delivery frequencies has been verified with the stores and the wholesaler. The sum of the sales and food waste data aggregated per period of one year, and has been used to calculate the number of delivered products which in turn has been used to calculate a food waste ratio. The food waste ratio is expressed as a percentage of a quotient between the amount of food waste and delivered products, as proposed by Eriksson, Strid [1]. When selecting product groups for analysis, the main focus was on top five product groups with the highest food waste ratios in selected stores.

Data analysis consists of two parts. In the first part of the analysis, food waste ratios have been observed in low, medium and high delivery frequency scenarios, for each product group separately. Three delivery frequency scenarios are represented by

four stores, where two stores are considered to have low delivery frequency per week, one is considered to have medium number of deliveries per week, and one is considered to have high number of deliveries per week. More details about the delivery frequencies are described in **Table 1**. The food waste ratio of each product group has been analysed in each scenario in terms of the hypothesis. It is important to note that in order to simplify the analysis, food waste ratios of product groups in low frequency scenario are average values of the two stores. Moreover, the Pearson coefficient of correlation has been selected due to its suitability for investigating the linear correlation between delivery frequency and food waste in terms of the hypothesis.

In the second part of the analysis, food waste ratios are compared among different product groups within the same delivery frequency scenario. Both parts of the analysis have used graphs and other functionalities of MS Excel 2010 software.

Reliability of data used in this case study is ensured by using the same type and number of products defining each product group in each store. Moreover, methods for capturing and calculating sales and food waste in each store are the same, since they are part of the same retail chain.

3 Case description and findings

All stores are part of the same retail chain and are customers of the same wholesaler. They are located within the similar traveling distance from the wholesaler. The product groups discussed are delivered from the wholesaler directly to the stores, and consist of meat, dairy, convenience food (e.g. sauces, tapas), fruits and vegetables.

The stores consist of two small stores with low turnover, one middle store with medium turnover and one large store with high turnover. Delivery frequency from the wholesaler to the stores is based on the turnover of each store, and applies that the higher the turnover, the higher the delivery frequency. Different product groups have different delivery frequencies within each store. For example, product groups of fruits and vegetables have one or two deliveries per week more than product groups of meat, dairy and convenience food. More details about delivery frequency scenarios per different product groups are described in **Table 1**.

Table 1. Delivery frequency scenarios per product groups

	Delivery frequencies per week		
Product groups	Low delivery frequency	Medium delivery frequency	High delivery frequency
Meat	2	3	5
Convenience food	2	3	5
Dairy	2	3	5
Fruits	3	5	6
Vegetables	3	5	6

The stores with low delivery frequency were placed to the left and the stores with high delivery frequency were placed to the right of the table. Similarly, the product groups with the low delivery frequency were organized on the top while product groups with the highest delivery frequency were placed on the bottom of **Table 1**. Thus, according to the hypothesis, the food waste ratio should be increasing, as coming towards upper left corner (darker boxes), and decreasing, as coming towards lower right corner (lighter boxes) of **Table 1**. **Table 2** describes the food waste ratios of each product group in three delivery frequency scenarios. Data from both tables are used as an input for further analyses in the next chapter.

Table 2. Food waste ratios of selected product groups in various delivery frequency scenarios

	Food waste ratios		
Product groups	Low delivery frequency	Medium delivery frequency	High delivery frequency
Meat	9,2 %	7,8 %	3,9 %
Convenience food	5,4 %	4,4 %	1,7 %
Dairy	5,4 %	2,1 %	0,5 %
Fruits	4,7 %	3,9 %	2,3 %
Vegetables	4,2 %	3,8 %	1,9 %

4 Analysis and discussion

Two types of analysis are presented in this chapter. The first analysis compares food waste ratios within three delivery frequency scenarios, for each product group separately. The second analysis compares food waste ratios among different product groups within each of the three delivery frequency scenarios.

4.1 Food waste ratios in different delivery frequency scenarios

In **Fig. 1** food waste ratios of each product group are observed in scenarios with low, medium and high delivery frequency. Overall, **Fig. 1** clearly indicates that the food waste ratio in high delivery frequency scenarios have lower food waste ratios than the low delivery frequency scenario, and it is valid within each of the selected product groups without exceptions.

For *meat products*, a decrease in the food waste ratio of around 15% can be observed when delivery frequency increases from two to three days and more than 50% when delivery frequency increases from three to five days. A very similar pattern can be seen in case of *convenience food*. Correlation coefficient for both meat and convenience food is -0,99 indicating very strong negative correlation.

For *dairy products*, a huge decrease in the food waste ratio of around 60% can be seen when delivery frequency increases by one day only. Even bigger decreases by around 80% can be observed when delivery frequency increases to five days a week.

This clearly indicates the sensitivity of dairy products to changes in delivery frequency. Correlation coefficient is -0,92 indicating a strong negative correlation.

For *fruits* and *vegetables*, a decrease in the food waste ratio of around 40-50% can be observed when delivery frequency increases by one day only, from five to six days. This is a much bigger decrease than the decrease of the food waste ratio of around 10-15% when the delivery frequency increases by two days, from three to five days. This kind of unexpected finding can be caused by factors that are not considered in this study, such as different planning principles or order management processes in particular store which might be significantly more efficient compare to the other stores. The correlation coefficients for fruits and vegetables are -0,92 and -0,84 respectively, and show relatively strong negative correlation. The vegetables group thus indicates to have the lowest correlation between the delivery frequency and food waste among the groups considered.

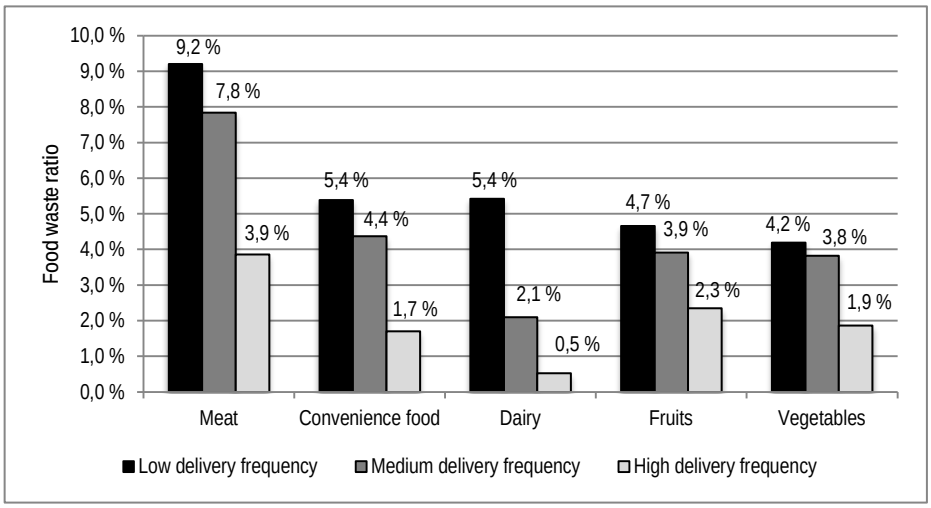

Fig. 1. Food waste ratios per product group in three delivery frequency scenarios

In summary, meat products, dairy products and convenience food strongly support the hypothesis. The fruits and vegetables product groups also support the hypothesis even though with a little lower correlation than the previous groups. These differences highlight the necessity of considering specific characteristics related to each product in order to analyse and explain food waste. The average coefficient of correlation including all product groups is -0,94 what is relatively strong correlation.

4.2 Food waste ratios among different product groups

In **Fig. 2** food waste ratios are compared among different product groups within each delivery frequency scenario. Assuming that the hypothesis is valid in this case as well, meat, dairy and convenience food should have similar food waste ratios, and higher food waste ratios than fruits and vegetables. It should be valid in each delivery fre-

quency scenario, since fruits and vegetables have always one or two deliveries more per week in each delivery scenario.

Analysis of the data indicates that the hypothesis is only partially supported in this case and it seems the food waste ratios of each product group behave independently from other groups, in each delivery frequency scenario (see **Fig. 2**).

Meat seems to be the group that supports the hypothesis most in comparison to the remaining product groups. In each scenario, the meat group has the highest food waste ratios, even in comparison to fruits and vegetables. Comparing with dairy and convenience food which have the same delivery frequencies, food waste ratios of meat are much higher than those of dairy and convenience food across all three scenarios. Since the shelf life and temperature sensitiveness are similar for these three groups, there might be other reasons explaining the deviation, for example different demand and supply pattern, processes and settings in order management or different principles used to decide order quantities, safety stocks or minimum order size.

Convenience food also records a significant decrease in the food waste ratio by almost 65% in high delivery frequency scenario compared to medium one. This decrease is so low that the food waste ratio of convenience food is below the ratio of fruits and vegetables groups even though they have one delivery per week more.

For *dairy products*, as the delivery frequency increases in the middle and high delivery frequency scenarios, the food waste ratio decreases significantly. The food waste ratio decreases by more than 60% in the medium delivery frequency scenario with one more delivery per week in comparison to the low delivery frequency scenario. Moreover, the food waste almost disappears in high delivery frequency scenario.

The analysis indicates that dairy products are most sensitive to changes in delivery frequency among the other product groups what can be caused by its product characteristics or demand pattern. Another explanation of such a significant decrease in middle and high frequent stores could be explained by different planning and ordering processes among the stores used in the case study.

Fruits and *vegetables* decrease food waste ratios gradually as the delivery frequency increases. It is interesting to highlight that even though fruits and vegetables have always one or two deliveries more per week than dairy products or convenience food, their food waste ratios are quite similar or even lower than food waste ratios of fruits and vegetables, especially in high delivery scenario. This paradox again indicates that some products have different product or market characteristics, or different methods for handling the products which may significantly influence the food waste ratio. It is, therefore, suggested to always consider differences between product groups when performing this type of analysis.

Overall, the lowest variations in food waste ratios among the different product groups seems to be in low delivery frequency scenario while biggest variations can be observed in high delivery frequency scenario.

Furthermore, it is interesting to notice that the rate of decrease in the food waste ratios of fruits and vegetables groups across three delivery frequency scenarios seems to be similar to the meat group. And similarly, the rate of decrease in the food waste ratio of dairy group across three delivery frequency scenarios seems to be similar to convenience food. Both phenomena should be investigated deeper in further research.

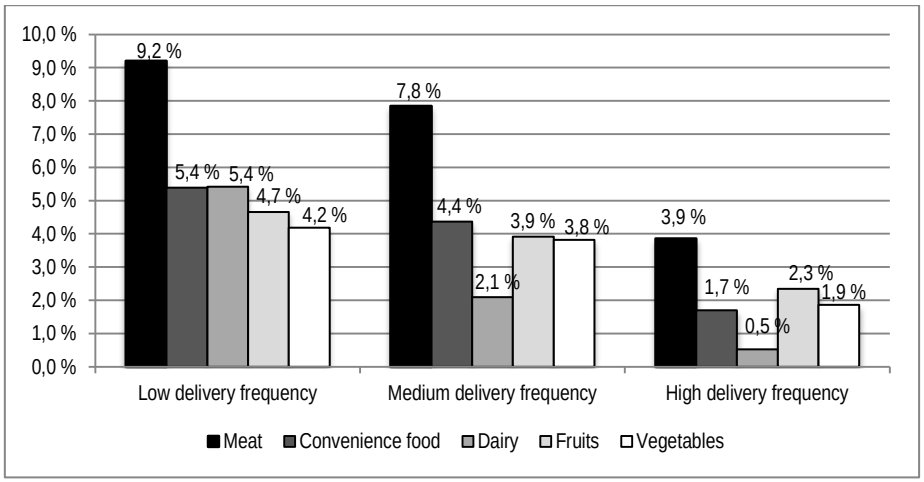

Fig. 2. Food waste ratios of selected product groups in three delivery frequency scenarios

5 Conclusion

This paper used a case study approach to investigate the linkage between delivery frequency and food waste in Norwegian food retail chain of chilled products. The findings of the first part of the data analysis show strong linkages between food waste ratios and delivery frequency for each product group separately. The average coefficient of correlation for all five product groups together is -0,94 what can be considered as very strong negative correlation, supporting the hypothesis – the higher the delivery frequency, the lower the food waste. Meat and convenience food product groups showed the highest correlation between delivery frequency and food waste. The second part of the data analysis revealed huge differences in food waste ratios across different product groups even though products had the same number of deliveries. In the medium and high delivery frequency scenarios, fruits and vegetables created more food waste compared to other product groups such as dairy or convenience food, even though they had more deliveries per week.

As a result of this, it is necessary to distinguish between product groups when analysing the linkages. One explanation could be that it is mainly because of the different product and market characteristics such as shelf life, temperature sensitiveness or demand pattern. However, the findings of the second analysis indicate that even the product groups with quite similar product and market characteristics, such as meat and dairy showed different food waste ratios while having the same number of deliveries. This indicates that various stores might be using different processes or principles other than delivery frequency which are specifically used for particular product group in particular store, e.g. batch sizes, package sizes, planograms, or hygiene and safety regulations. These assumptions should be considered and investigated deeper in the future research.

The main limitation of this study is a small sample size which restricts the generalization of the findings. In future research more stores should be added to the case study in order to increase validity of the findings.

The study contributes to theory by testing the hypothesis about the linkage between delivery frequency and food waste. It also discusses the differences between food waste ratios among different product groups within three delivery scenarios. Practitioners might use the findings of the study in order to understand how levels of food waste for the abovementioned product groups behave under various delivery frequency scenarios. Considering these findings they might better adjust their current processes and planning settings in order to minimise costs related to food waste.

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