Temperature controlled supply chains call for improved knowledge and shared responsibility

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Published in:
Proceedings of the 16th Annual Conference Nofoma

2004

TEMPERATURE CONTROLLED SUPPLY CHAINS CALL FOR IMPROVED KNOWLEDGE AND SHARED RESPONSIBILITY

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ABSTRACT

In modern industrialised society prepared meals and eating out of home is an increasing phenomenon. This develops new business opportunities for food manufacturers, since they need to create more convenience to the consumers through food that can be prepared and served quickly. However, the new food products require increased quality and safety and thereby more controlled distribution. The issue in distribution of temperature sensitive food is to store, handle and transport products to minimal cost with keeping as much as possible of original quality and shelf life.

The paper describes how the system for distribution of chilled food, from manufacturer to end-user, operates in Sweden, with focus on temperature keeping and shelf life. A comparison to the UK is made. The aim is to identify critical points in the food supply chains and to suggest ideas for improvements.

The studied chill chains all show critical points in terms of temperature handling and are in many ways lacking in temperature control. The UK market, however, already has really temperature controlled food supply chains. The paper suggests attitudinal changes towards overall supply chain responsibility, better resource utilisation and increased knowledge among actors.

Key Words: food supply chain, chilled distribution, food safety, food quality, temperature control

1. Introduction

Modern industrialised society has a higher pace and an obvious change of lifestyles among consumers. Former studies show that food consumption will be affected by a number of trends in society such as health concerns, environment, convenience etc. (Gerding et al. 1996). Looking to the longer terms consumers' willingness to eat out of their home will most likely increase in Sweden, as has already happened in the UK. Higher disposable incomes, new lifestyles, greater choice of eating out and lower price per meal will all impact the trend. The trends and lifestyle changes create new business opportunities for food manufacturers, in the way they need to create more convenience to the consumers through food that can be prepared and served quickly (Axell 2001). The trend among consumers to prefer fresh products is also assumed to increase which leads to that chilled food, particularly prepared chilled food, is now more and more competing with frozen counterparts. Today there is fifteen times more chilled food than frozen food transported through Sweden (Lindborg 2000). One important issue in the transfer from frozen to chilled food is the issue of *safety* that is on everybody's mind and identified as an increasing concern.

The new trends and lifestyles put stern requirements on new food products with a safe and quality controlled distribution. In order to highlight safety and quality, temperature control is an important issue in chilled food distribution (Woolfe 1992). Good temperature control from production to retail sale is the basis of maintaining quality and safety in chilled foods. The issue in distribution of temperature sensitive food is to store, handle and transport products to minimal charge with keeping as much as possible of original quality and shelf life (Björklund 2002). In order to succeed in this, all activities have to take place under temperature-controlled forms, which is called the chill chain.

However, the chain that links this flow of chilled food is complex. The food products are passing from one manufacturer to another, via different wholesalers, before reaching the retail store and eventually the consumer. With that many intermediate steps involved, it would be rare to find the responsibility for the whole chain resting with one company alone (Woolfe 1992). On the other hand it is a problem to achieve a shared responsibility among the different actors in the chain.

The purpose of this paper is twofold. Firstly to describe how the system for distribution of chilled food operates in Sweden today, with certain directionality on temperature keeping and shelf life. The study comprise the food supply chain from food manufacturer to the end user, i.e. end consumer, or large-scale households such as restaurants, hospitals, canteens etc. that serve food to consumers. Secondly the purpose is to identify critical points in the food supply chain and to suggest factors for improvements from holistic supply chain perspective. Critical points can be defined as a point where the food product spends time in an environment that has a higher temperature than the recommended temperature for an optimal quality.

2. Research method and data collection

A qualitative case study is used for analysis of the Swedish supply chain for chilled food. According to (Ellram 1996) case studies focus, on situations in real life settings with a set of relevant boundaries, such as the supply chain used in this study. The input for the analysis is based on interviews and observations, with respondents from major actors in the Swedish food industry. Case studies emphasise the element of understanding a studied phenomenon, and stress an interpretive approach, (Denzin & Lincoln 1998) which is suitable for this study since limited former research and written material can be found in the area of critical points

regarding temperature handling in the food supply chain. The selection of respondents is based on the role they play in the supply chain of chilled food from production to consumption. The aim for the input was to get as wide input as possible why respondents from different actors with different hierarchical levels were chosen. Input was also gathered from actors peripheral to the supply chain such as insurance companies and authority institutes, in order to add additional perspectives to the study.

Table 1: Setup of respondents

	Producer	Wholesaler	Transporter	Large-scale household	Retailer	Authority
Managing Director	4					
Operations manager	3			4	3	
Logistics manager	3	4	2			
Logistics operation	9	3	2			
Quality manager		3				
Quality control	5	2				6
Insurance						3
Warehouse manager		1				
Warehouse operation	2	1				

3. Food supply chain

A food supply chain is complex, time-critical and dynamic. Typical steps in the food supply chains are agriculture, food manufacturing, food wholesaling, food retailing and, food service and catering, as illustrated in Figure 1.

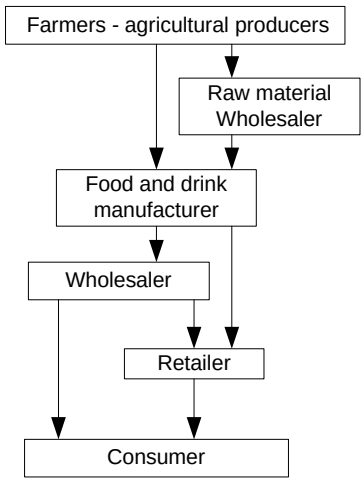

Figure 1: A generic food supply chain based on scheme from (Bourlakis & Weightman 2003) and from input in the study

Chilled food requires a temperature controlled food supply chain. A temperature controlled supply chain includes all storage and transport facilities necessary to ship a temperature sensitive product from manufacturer to end user and is characterised by the demand of being frozen, chilled or ambient (Taylor 2001). The complexity and time factor is even more critical for chilled food than for frozen and ambient equivalents, since chilled foods require both higher speed due to shorter shelf life and better product integrity due to safety in the supply chain. When food products are moved forward in the supply chain from manufacturer to the consumer, product integrity is vital and the food has to be of certain quality at the point

of consumption. Storage, handling and transportation all have effect on food quality and shelf life. Shelf life calculations for chilled food assume an unbroken chill chain and need to take into account the time the product will be in the hand of the consumer prior to consumption (James 1996). Good relationship with distributors can result in better supply chain performance and thereby safer and better quality food.

Different food categories put different requirements on the food supply chain. The prepared food supply chain is identified to be more critical from a temperature perspective than the others since the food is based on a mixture of different ingredients and the cutting into thin slices provides larger surfaces and thereby greater exposure to microorganisms. Besides the prepared food industry the meat industry is also exposed to the requirement of thinner slices for cured meats and provisions (Smith & Sparks 2003).

In the distribution of chilled food all businesses that involve any kind of professional food handling are, according to law, obliged to practice supervision of its activity in order to prevent health risks. One of the foundations in this supervision is temperature registrations and documentation, where every actor has the responsibility to measure and register the food temperature at a handover from one actor to another (Svenska Kyltekniska Föreningen 2000).

3.1. Food quality deterioration

The shelf life of food products in Sweden is an indicator of level of quality. All food products have to be marked with either “best- before-date” or “last-date-for-consumption”. The latter is used for more sensitive food like fresh meat, fish and chicken (Livsmedelsverket 2004a). Therewith the “best- before-date” shall be set so that the food if stored under the right conditions and in an unbroken package shall be possible to consume some additional time after the set date (Livsmedelsverket 2004a).

The two most important factors concerning the shelf life of a product are time and temperature. Most of the deteriorating changes that take place in food are temperature dependent and occur at a slower rate at lower temperatures (Hernandez 2001). The most sensitive type of food in this respect is chilled food, while frozen food is less sensitive due to the lower temperatures and ambient food is less sensitive due to other processing or packaging techniques.

“Chilled food” is usually defined as chilled prepared food that should be stored at the statutory maximum temperature of +8°C in Sweden (Svenska Kyltekniska Föreningen 2000). However, for most chilled food products the optimal and recommended temperatures are under +4ºC. The statutory +8°C puts Sweden as the second nation from the bottom of the list of countries in the EU, with only Italy having higher statutory cold chain temperatures! And even worse - the statutory +8°C in Sweden is moreover often infringed (County Council of Skåne 2002). If the temperature is infringed, the shelf life will be affected which will give an uncertainty if the “best- before-date” is valid.

As mentioned above the temperature demanded by the law for many food products differ from temperatures recommended by experts in the food industry, as shown in table 2. Furthermore, the temperatures that are optimal for products are often even lower than the recommended. This means that when products are stored at temperatures according to the law, they might still loose quality quicker than in the optimal or recommended temperatures (Karlberg & Klevås 2002)

Table 2: Maximum temperatures according to law, compared to recommendations.

	Law , °C	Recommendation, °C
Fresh fish, not on ice	2	2
Smoked, raw spiced fish	8	4
Chicken	4	4
Meat	8	4
Minced meat	4	4
Cured meat	8	4
Prepared food	8	4

4. The food supply chain in Sweden

The Swedish food industry can be characterised as having a large amount of producers, very few wholesalers and many retailers. The producers deliver to all wholesalers (Axfood, ICA and COOP), while the wholesaler delivers to a few retailers only. This is in most cases regulated by the relationship between the wholesaler and the retailer where the wholesaler and the retailer in Sweden often are under the same umbrella of companies.

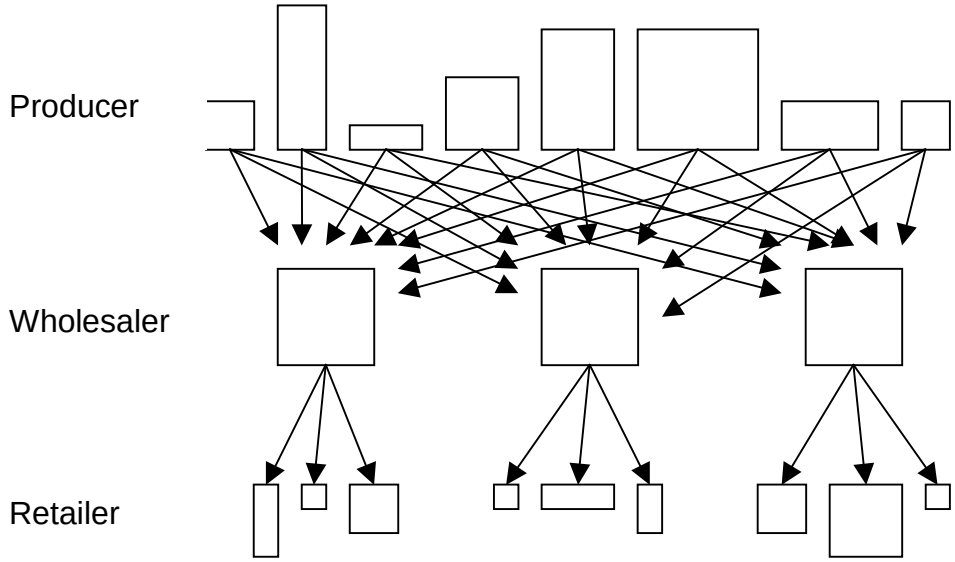

Figure 2: Principle description of flow from food producers to retailers in Sweden

The major difference between the retail food supply chain and the foodservice supply chain, i.e. the chains that supply restaurants and large-scale households with food products, is that the customer (e.g. the restaurant) is not obliged to one wholesaler or supplier. The amount of wholesalers is on the other hand very limited, even in the food service sector. With few wholesalers both in the retail and in the food service sector the power in the Swedish food supply chain is mainly with the wholesalers. The responsibility for the product quality and safety at the point of consumption is on the other hand with the manufacturer.

The issues of mixed ingredients, mixed food products and more sliced and prepared foods put larger requirements on quality control and secure temperature handling in the food supply chain. Meanwhile, the market demand for these products is constantly increasing and the food manufacturers produce more prepared foods made up from a larger variety of ingredients (Smith & Sparks 2003).

4.1. Critical points in the Swedish chill chain

Our study indicates that the supply chains for chilled food in Sweden are in many ways lacking in temperature control and should give cause for concern. Our study also indicates a low level of food technology knowledge at operational level in the entire chain.

Critical points in terms of temperature handling can be identified in the studied chains, although very few of the interviewed actors admit problems in chain. However, they often claim or believe that problems might occur at small retailers. Test results from government authorities, however, point out that temperature related problems occur within the whole chill chain among all actors, large and small. Critical points were found in the entire chain in our study, both within internal logistics at each actor and in the interconnections between actors. In internal logistics incorrect temperatures were found to occur mainly in transports and at retailers, restaurants and catering kitchens. In external logistics, inbound and outbound from the different actors, it was also identified from the interviews and observations that the major problems occur, i.e. in the shift from one actor to another. These identified critical points are marked in the generic supply chain illustrated in Figure 3.

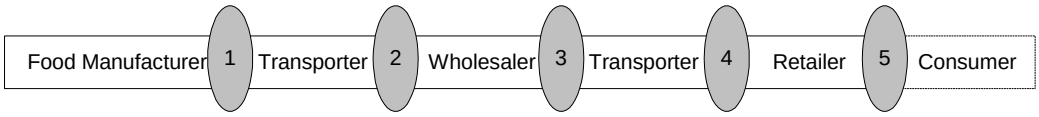

Figure 3: Generic food supply chain

Based on the analysis from the interviews and the observations at each actor the critical points in the transfer from one actor to another are summarized in Table 3. In order to give a deeper understanding of the summarized critical points, each actor in the chain is described in more detail under specific headings after the table. The food handling and the critical issues identified in the study are elaborated on more in detail under these headings.

Table 3: Critical areas and concerns

Critical area	Concerns
1	Product cooling prior to palletizing or loading Lack of temperate air lockage at dispatch Temperature requirements put forward to transporter→ lack of self control Limited food technology knowledge at operational level
2	Cooling aggregate only for temperature keeping – not for cooling Limited documentation of temperature loggers Combined transports Limited or no food knowledge
3	Mixed temperature zones in dispatch and loading areas Waiting times at dispatch and loading Limited or no food knowledge
4	Several stops at retail → heats up cooling area in truck at each stop Return goods heat up cooling area Lack of temperature controlled area for incoming goods Waiting times for unloading Cooling cabinets in retail store not reliable Lack of temperature control
5	No knowledge about temperature exposure previous in the chain No knowledge about validity of "best before date" Different ways of handling food in household Different levels of knowledge about food hazards Different exposure of food at transport from retail to household

4.1.1. The producers

In Sweden there is a law about the producers responsibility. It says that the producer, with a few exceptions, is responsible for the quality of the product throughout the distribution chain to the consumer (Karlberg & Klevås 2002). Furthermore, the producers are responsible for product marking i.e. to set the temperature requirements on the product. The set temperatures are then valid throughout the entire chain.

The study indicate that the manufacturers in general can be considered professional in terms of temperature keeping and in putting requirements within their own part of the chain. However it indicates some deficiency in the cooling of products prior to dispatch, both with large and small manufacturers. When ready products are put onto pallets as part of the production the food in the center of the pallets require long cooling time which will be a risk since the time in some cases will not allow the product to reach the required temperature before palletizing and dispatch.

The study also indicates that there is a lack of temperature control at dispatch at the producer and that some producers rely on the cooling aggregate in the truck to cool the products to the required temperature. Furthermore only a few producers have air lockage at dispatch.

4.1.2. The transporters

The transports are an important step in the food handling, since an unbroken chill chain is essential. Speed and reliability of transports is of great importance since the shelf life for

chilled products is limited. Furthermore chilled products require special equipment in transports for keeping temperatures.

The study shows that the transports to large retailers are normally made in separate trucks for colonial, chilled and frozen food respectively, while food transports to smaller retailers are usually made as combined transports from wholesale dealers. This means that food with different temperature demands is transported together in the same vehicle. Multi-temperature zone vehicles are sometimes used when transporting food with different temperature requirements, although these trucks can be of very different advancement. One actor on the Swedish market is trying a new three zones cabinet, with separate evaporators for the different zones, frozen, chilled and ambient. The solution is however expensive and the customers are usually not willing to pay for this. The only exception is McDonalds, who normally put tougher requirements on the producers and transporters than other customers in the chain (Ovesen 2004). At combined transports (different food categories in the same truck) a compromise of temperatures is made which has a negative quality effect on certain food, i.e. the food that is transported in another temperature than recommended.

When considering transport equipment it is important to realize that no equipment neither cabinets nor trucks for transport are made for cooling, only for keeping temperature. The capacity of the cooling aggregates does not have capacity to cool products, which means that products with a higher than required temperature will cause increased temperature and thereby a higher temperature in the truck than recommended. This is a critical issue since it is identified in the study that some producers rely on the transporters to cool the product to the required temperature. Another problem in the transports is to keep an even temperature in the cold cabinet especially if many stops occur. Furthermore the study indicates that temperature controls are very rare in this part of the chain and there is a lack of temperature loggers. Besides, print outs from temperature logger are only made if there is an indication of any mistakes. Former studies also indicate that one third (1/3) of the chilled food in Sweden does not hold the right temperature at transport (Livsmedelsverket 2004b)

Our study also indicates that a limited knowledge of food technology and deteriorating processes may cause less suitable handling at the transporters.

4.1.3. The wholesalers

In the food supply chains the trend is that more and more food is delivered by wholesale dealers rather than by producers. At the same time the wholesale dealers are centralizing their distribution centrals so that the transport distances increase. The result is that the wholesale dealers become more powerful and quality concerned. Longer distances and more requirements from the wholesalers will put more pressure on the transporters.

In general the study indicates that the wholesale dealers can be considered professional in temperature control of incoming food and in the handling as such. However negligence of documentation is identified. The temperature instrument used is usually of laser type that is identified as easy to handle on large amounts but hard to handle in a correct way. As an example the measurement is made on the surface of the package not on the product as such for obvious reasons.

The wholesalers have temperature zones both at reception and at dispatch; the only concern is that one temperature does not satisfy the need for all product categories.

4.1.4. The restaurants or large-scale households

Restaurants and large-scale households in Sweden receive all food via combined transports with frozen, cold and ambient food in the same transport. This is seen as positive since it reduces the amount of deliveries to each restaurant. The driver makes unloading from the truck directly into the refrigerators. However, from a food quality perspective a combined transport affect shelf life since it is a compromise for certain food categories.

In catering kitchens modern cooking has made its entrance. Cook chill, sous-vide[1] and cap cold[2] are all techniques for distributing finished meals chilled. These new methods make however new demands on the chill chain. The finished product shouldn't be exposed to temperature exceeding 3ºC, which is a problem since the chill chain in Sweden is based on the temperature 8ºC. Since food cooked in these ways don't show the natural signs like bad smell and look when they get bad, better controls of the temperature are important in order to avoid health risks (Björklund 2002).

The study indicates that many, restaurants and catering kitchens, don't practice the temperature supervision to a sufficient enough extent. The reasons are insufficient knowledge, shortage of staff and economic aspects. The consequence is that the temperature related shortcomings don't get revealed and no action is taken. In the extent this leads to health risks, shorted shelf life, quality problems and increased wastage. Shortages in the controls make it difficult or impossible for the different actors to complain defective products to earlier stage in the chain. (Björklund 2002).

4.1.5. The retailers

The retailer is the last professional actor in the chain and thereby the one that suffers from accumulated temperature mistreatment. Reception of food in retail is very often taken care of by the transporters. In some cases the driver even puts the food into the right shelf or cabinet in the retail store. This depends on the relation between the wholesaler and the retail store.

Former studies show that retail display of chilled food is found to be the weakest part of the chain, with a broad variation in temperature from cabinet to cabinet (James 1996). Temperature controls of frozen and chilled cabinets shall be made in the self-control programs that are stated by the law for each actor in the chain. Yet, temperature control is very seldom made in the retail part of the chain and the retailer usually trusts the actor prior to them in the chain. Other critical areas in retail are at incoming goods and at handling of the food outside temperate areas. The study indicates a lack of temperature-controlled areas for incoming goods at many retail locations, and occasionally food is placed outdoors on a loading platform.

4.1.6. The consumers

The consumer is the last actor before consumption of the food product. This is the step where the accumulated mistreatment is built up and in worst case gives the most serious effects. It is for example identified that a too high food temperature is the most common reason for food-spread diseases (Axell 2001).

All refrigerated products are exposed to temperatures out of the refrigerated control during transport from retail to consumer. This is the part of the food supply chain where the

[1] Sous-vide is prepared food chilled in vacuum

[2] Cap–Cold quick cooling after cooking, no additives to the product

knowledge is particularly limited and the consumers have no knowledge about how the product have been treated from the producer to the retail, thus not knowing whether the printed best before date is valid or not. Due to limited knowledge in the field the consumer does not put any specific requirement on knowing more.

4.2. A comparison to the UK chill chain

Food supply chains in the UK are typically set up by agriculture, food manufacturing, food and drink wholesaling, retailing and food service and catering, which is similar to the setup in Sweden. Supply chain management in grocery retailing is, however, more mature and better experienced in the UK compared to other European countries (Fernie, 1999).

The UK is considered to be in the forefront in partnership with professional distributors contrary to other European markets where logistical support to food retail stores is much more fragmented (Fernie, 1999). The grocery retailers in the UK did centralize their distribution early and took the supply chain control away from the manufacturers. This control led to an emphasis on service, quality and reliability when selecting distributor (Paché, 1998). This centralization and control resulted in increased retail power and subsequently less power to the wholesalers of the chain (Bourlakis & Weightman 2003), which is different from the power situation in Sweden.

The food retail market in the UK is relatively static but there is an intense competition among the major supermarkets (Tesco,Sainsbury's, Asda and Safeway). Despite competition a voluntary code of practice was adopted in March 2002, designed to improve relationship and enhance collaboration with suppliers (Duffy & Fearne 2003). In this respect Sweden is immature.

Central control of the retail operations in the UK also make the buying process less complex and more dynamic than in for example in Sweden (Johansson, 2002). The retailers in the UK are moving earlier and faster than in Sweden when it comes to sharing information with suppliers. Former studies also show a shift from a push to a pull strategy in UK food retailing which means that buying starts with selling to the consumer rather than buying from the manufacturer (Johansson, 2002). Deliveries of food in the UK have become more just-in-time, based on point of purchase data, which leads to greater flexibility of order size, more frequent deliveries and smaller delivery windows (Goldring 1998). One example of this is the situation with the daily purchase of primary produce in the UK which is different compared to Sweden where purchase of fresh produce occurs only weekly, which have a negative effect on the food quality. The role of fresh produce as a strategic segment has changed the past ten years in the way that it has doubled the shelf area and moved from back of the store to front of the store (Fearne & Hughes 2000). Furthermore, some fresh produce products have been identified as a category for which shoppers will switch or select store. The driving force for prepared fresh product is convenience

Prior to 1990 UK had very few regulations regarding temperature control of food, however a number of temperature controls of production, distribution and sale of food products have been introduced after 1990 (Woolfe 1992). Contrary to Sweden the buyer is according to the Food Safety Act (1990) urged to take reasonable steps in ensuring safe food from suppliers (Fearne & Hughes 1999), while the producer has the full responsibility in Sweden.

In terms of temperature control in the food supply chains a really temperature controlled supply chain with *super chilled* food is already in place in the UK (Smith & Sparks 2003), but economy is so far said to prevent this from happening in Sweden. The *super chilled* food product concept can be defined as "to keep the product at a temperature just above its freezing

temperature" which gives a higher safety than for chilled food and at the same time a fresher image than frozen food.

Smith and Sparks suggest (2003) three levels of temperatures that suit different food categories: cold chill, medium chill and exotic chill. The cold chill relates to 0-+1 degree for meat and poultry, + 5 for some pastry, butters, fats and cheeses and +10-15 for potatoes, eggs exotic fruits and bananas. Tesco now has two chilled groups, +1 and +12, and –25 degrees for frozen (Smith & Sparks 2003).

A study made on the food supply chain in the UK identified three points of concern in order to keep a constant temperature from manufacturer to retailer.

- The produce has to be chilled direct after harvest and keep the right temperature at loading onto trucks
- The cooling equipment in the trucks has to be well functioning
- Loading and unloading has to be made in temperate air lockage, if that is not possible the maximum time outside of the temperature zone is 20 minutes.

Investments in the supply chain were made in the UK according to the critical points above, which resulted in an improved product quality and thereby a prolonged shelf life. The increased quality and prolonged shelf life entailed an increased demand for the products from the consumers (Smith & Sparks 2003).

5. Suggestions for improvement

The study shows that the Swedish consumer might experience products with lower food quality than achievable, shorter shelf life than possible, more waste than necessary and in worst case also health risks due to a combination of limited knowledge in all steps in the food supply chain and a certain negligence in the food handling.

This leads to a suggestion for more focus on certain areas in order to improve quality, shelf life and food safety.

Knowledge & communication

Throughout the whole line of business most people are aware of deficiencies in the chilled food distribution but in order to achieve improvements there has to be food knowledge in every link in the chain. Knowledge is the foundation to understand, accept and thereby change behaviour toward more discipline throughout the chain and to realization that quality losses cost money. The majority of the personnel within the food supply chain don't have any or very little food technology education. Step one in an action program should consequently be education.

Resources

The public authorities, which are in charge of controlling the distribution, have too little resources (money/time) to make adequate inspections. This leaves a big responsibility to the food industry. The dilemma is whether to have full lorries, focusing economy, or the right temperature for every product, focusing quality. The temperature demands have to give way for economizing on transport costs. Furthermore it is shown in the UK, that investments made for improving the chill chain have resulted in longer shelf life, higher quality of the food products, and thereby an increased demand for the same products from the consumers. The longer shelf life also means less wastage. Identification and registration of wastage would

point out the amount of money that is lost because of temperature mistreatment. This would be an incitement to take action against the problems and a suggested action for the future.

Attitudinal change

A change in attitude towards supply chain thinking and collaboration is necessary. Today the participants in the supply chain rely on the next link. The lack of claims is seen as a proof of an intact food chain, rather due to the fact that temperature mistreatment does not show results until the last steps in the chain, temperature measurements and better control of the food supply chain is to recommend. A pro-active mind, where an overall control system with available data for all actors in the chain based on collaboration and shared responsibility can be one solution.

Participants want to optimize their part of the distribution. No one considers the whole supply-chain and sub optimizing might be the result. Today there is no cooperation with members of the whole food chain. By creating such an organization a lot of misunderstanding could be eliminated and the knowledge and understanding for different problems in the chain could increase. A code of practice as in the UK could be one solution for improved collaboration. Through improved collaboration, as in the UK, it will also be possible to get closer to just-in-time delivery in the Swedish food supply chain which will improve quality of fresh product and also reduce wastage.

Shortcomings in the chilled food chain become an obstacle for developing new products. One technical option that is pointed out for an increased safety is s*uperchilled food products*. This means a differentiated cool chain depending on the freezing temperature of the product.

When it comes to information UK studies (Kuznesof & Brennan 2003) suggest that communication about food safety and food risks has to be conducted in an integrated manner with food industry, government and consumers. This reasoning is also applicable for the Swedish study was a lack of integrated communication is seen.

Mindset from FIFO to LSFO

Well functioning supervision of activities, of the actors themselves, is vital to secure the chill chain and prevent temperature related problems. Simple and cost efficient technology in combination with routines, developed by the staff themselves, is probably a big part of the solution.Technical facilities make it possible to ensure a product's actual time and temperature of exposure, i.e. the most important factors that affect the shelf life and quality of a product. By introducing such technical solution attention can be drawn to the actual points of problem.

This makes way for future gods control on the reference of the actual shelf-life of a product, LSFO (Least Shelf-life First Out), instead of FIFO (First In First Out) and sell-by-date marking that is determining today. The benefits from using LSFO are that the quality of handling is considered from producer and forward, which results in extended shelf life for correctly handled products and shorter for temperature mistreated. In the end this means reduced wastage, safer food and higher product quality.

6. Conclusions

The study indicates that the supply chain for chilled food in Sweden is in many ways lacking in temperature control, which should give cause for concern. This can lead to that the Swedish consumer might experience products with lower food quality than achievable, shorter shelf

life than possible, more waste than necessary and in worst case also health risks. Shortages in temperature controls make it difficult or impossible for the different actors to complain defective products to earlier stage in the chain. This affects actors in the later stage of the chain of distribution, even if the temperature mistreatment has taken place in earlier stages.

In order to being able to solve the temperature related problems, one can conclude that monitoring and mapping of the actual food supply chains in order to identify critical points is necessary as an initial step.

In order to get an increased safety and quality in the distribution of chilled food, the following suggestions might be one way to go

- Increased knowledge through food technology education in all steps of the supply chain.
- Change in attitude towards supply chain thinking through less sub optimizing, and more responsibility by each actor.
- Supply chain practice through improved collaboration between supply chain actors
- Focus the resources towards quality rather than economy – since a higher quality will drive demand and thereby defend economical investments.
- Facilitate goods control, by using least shelf life first out “LSFO”, by introducing technological tools for measurement of accumulated temperature mistreatment.

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