

Packaging development process for cardboard packages with direct food contact

Mena Hanna

MASTER'S THESIS

Packaging Logistics
Lund University



FIPDes

Food Innovation & Product Design

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Abstract

Title (in English): Packaging development process for cardboard packages with direct food contact.

Title (in Swedish): Utvecklingsprocessen för kartongförpackningar med direkt livsmedelskontakt.

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Issue of Study: To help the corrugated board industry to build knowledge in order to produce safer packaging for direct food contact. Additionally, to improve external communication with their customers while internal communication through the main department's involvement in packaging development process. Furthermore, to understand the current situation within a packaging company and to suggest more responsibilities to each department in order to produce safe packaging and develop tools that can help different actors throughout the development process for better understanding of the nature of each product and identify the requirements of each product from a food safety perspective.

Purpose: The main goal of this thesis is to assess the current packaging development process at one of the leading Swedish corrugated packaging companies, from a food safety perspective. The focus of the study was based on the following questions: (1) Does the process in early stages identify whether the packaging to develop is suitable for direct food contact? (2) What is lacking in the process in order to ensure that direct food contact requirements are sufficiently considered in development projects where food safety requirements apply?

Method: The study was based on qualitative-methodology research. The first part of the study was obtained through review of relevant literature, books, publications, in the field of new packaging development and food safety of corrugated boards. Another type of data was collected through careful selection and interviewing. Ten semi structured interviews were conducted with packaging managers, professors and experts in the food and packaging industry. Also, food safety

authorities were contacted for better understanding of derivatives and legislations related to food contact materials and what companies should do in order to produce safe packaging with direct food contact.

Conclusion: The focus of this study is to assess the current process of corrugated packaging development at Company P (Sweden) from a food safety perspective, to identify what is lacking in the process to ensure that packages intended for direct food contact requirements are sufficiently considered in development projects as well as to get a holistic view of food companies and experts opinions about using cardboard (corrugated and solid) in the food industry, as a primary and secondary packaging.

There are more guidelines needed in the production of packaging intended for direct food contact, in order to produce safer packages. Responsibilities were suggested to each department to help produce safer products.

Each food product has specific packaging requirements. To help in identifying and addressing these requirements, a template for sales, logical diagram and system template for various departments were designed to facilitate and improve internal communication within the company. Additionally, the templates were constructed to help the packaging company in their development process, such as asking the appropriate questions to the customers in order to identifying the needs of each product.

Using a virgin material for packages intended for direct food contact can be a short term and safer solution for any packaging company which does not have full control on the migration limits of hazardous substances for the recycled raw material. Another solution can be through developing more sustainable packages made from recycled material with functional barriers to prevent hazardous substances to migrate to food. A packaging company can have a unique selling point if they could produce recycled packages which are more environmentally friendly and lesser in cost.

Key words: Corrugated packaging, new packaging development, mineral oils, food safety, recycled fibers, virgin fibers, migration.

Executive summary

Introduction

The corrugated board is considered as the most used transportation packaging in the world. Forty percent of corrugated packaging is used for packing food products but only 4% of this is actually used in direct contact with foods, while the rest is used as secondary packaging (European Corrugated Industry, 2014). Corrugated packaging is used to protect food products and to help minimize food waste. Cardboards are widely used in food; however, only a small percentage is used for direct food contact as shown in recent statistics; examples of these include pizza cartons or boxes for hamburgers and sandwiches. The examples stated could be considered as high risk applications due to relatively high temperature of the food when initially packaged and the high fat content of the food products, which can contribute to faster migration rates of unwanted substances from the packaging to the food.

It is still a challenge for food and packaging companies to address all known and unknown substances and use the right material for each product. There is a responsibility for packaging manufacturers to ensure that cardboards meet all the requirements of food safety and hygiene. Companies should have a system to identify the risks and to choose the appropriate material which can be used when food contact is the case. Another issue is the internal communication between different departments inside the company (e.g., sales, design, purchasing and production) to identify whether the produced packaging will have direct food contact or not from early stages of development. If internal communication works properly, the sales department can ask the right questions to the customers, and the design department can make the proposals that suit each product's needs. Production can use the right material in manufacturing and the purchase department can buy the safe material, depending on the type of the packaged food.

Purpose of the research

The main goal of this thesis is to assess the current packaging development process in one of the leading Swedish corrugated packaging companies, from a food safety perspective focusing on the following questions:

- a) Does the process in early stages identify whether the packaging to be developed is suitable for direct food contact?

- b) What is lacking in the process in order to ensure that direct food contact requirements are sufficiently considered in development projects where food safety requirements apply?

To fulfill the purpose, the following sub-objectives have been identified:

- 1) Design a supportive tool in the form of a template to help designers and sales representatives to ask the right questions before or during the project, in order to recognize if direct food contacts is the case.
- 2) Explore the current system and give suggestions on how to improve the data collection and internal communication between different departments within the company (e.g., sales, design, purchase, production).

Methodology

The study was based on qualitative methodology research. The first part of the study was obtained through a review of relevant literature, books, publications, doctoral theses, journals in the field of new packaging development and food safety of corrugated boards. Another type of data was collected through careful selection of interviewees. Ten semi-structured interviews were conducted, which included:

(1) Main departments involved in the packaging development process. (2) Several packaging experts working in food companies in Sweden and (3) Professors and academic experts in the field of packaging and food industry.

All interviewees were selected based on their expertise in the field. All interviews were performed face to face. Before each interview a copy of the questionnaire was sent to each interviewee in advance by email. A short presentation of the project was performed and its purpose was stated before starting the interview. The length of each interview was approximately 50 minutes. The researcher recorded and transcribed each interview, and interviewees were kept anonymous and were coded to specify their position and years of experience, among other details.

Thematic analysis was used to categorize data into different topics. It was also used to analyze and describe the data in profound ways and to build a proper structure to the research paper.

Results and Discussion

According to the respondents, there are four departments involved in the packaging development process within the packaging company (Sales, Design, Production, and Purchase). Sales and design have a follow up communication and involvement in the new packaging development and have a close communication with their customers (food companies) to identify the project and customer needs for different products.

There was a need to understand the role of each department in order to produce packages with direct food contact. As each food product has its own requirement, the

food company needs to answer some questions about the nature of the product, product requirements and customer requirements. A tool was developed to assist packaging companies to ask the appropriate questions. The author found that it would be beneficial for the sales department to use a checklist for food products to ask specific questions to the food producers (customers), in order to determine the appropriate packaging material.

The author suggested a template to improve internal communication, which can be added to the system as a tab specifically for food packaging requirements and inputs for different products. This tab on the wizard can be called 'Critical information for food products and food safety' where all the necessary information (about the packed product, temperature, contact with packaging etc.) was developed. Interviewees pointed that by answering those questions and understating the nature of the product, which will reflect the need for specific materials and processes to use in the production to avoid all possible risks, and to produce safer packages.

Regarding the used material, Company P uses only virgin fibers for direct food contact. Interviewees from food companies mentioned that recycled material should be considered, as it is a sustainable resource, but it must be handled correctly to avoid all the possible risks. Other interviewees mentioned that in some cases, there is a need for higher quality of materials to minimize the risk, and debates show that packaging and food companies have to be more vigilant towards this, and not only be cost driven.

The EU does not have a harmonized legislation for the use of food contact paper and board materials (Albu & Buculei, 2011). More work is needed by food authorities and researchers to help packaging and food companies produce safer packages for foods in the future. Interviewees from food companies mentioned that if legislations get stricter that will help them to be more careful during production.

Food companies as well as the final consumers will be willing to pay more if packages were proved to be safer than its competitors, and this can open new markets to packaging companies and increase their sales. The author believes that efficient functional barriers which can be, for example, PET or other functional barriers, can be used. Another question that should be addressed then is about the separation of those materials when it comes to recycling.

It should also be considered that only using different materials will not prevent all the possible risks of contamination, as contamination can occur from other sources, e.g. through transportation or machinery, which can have dangerous levels of mineral oils

or heavy metals that might transfer to packages, then afterwards to the food itself. Thus, the best solution is to have a complete system which assesses all the possible risks.

The author assessed the current situation within the packaging company and suggested further responsibilities which can be added to each department involved in the packaging development process, in order to produce safe packages for direct food contact.

Summary of the company’s current situation and the author’s recommendation on department responsibilities

	Current situation of responsibilities	Recommendations for direct food contact packaging
Sales department	<ul style="list-style-type: none"> • Collects all needed information and customer requirements 	Ask the appropriate questions regarding food safety requirements, depending on the nature of each product
Design department	<ul style="list-style-type: none"> • Packaging concept • Design • Printing process 	Documentation: <ul style="list-style-type: none"> • Migration data • Amount of ink applied to package. • Adhesive and ink selection depending on product requirements.
Production department	<ul style="list-style-type: none"> • Packaging production • Production risk assessment • Quality assurance 	<ul style="list-style-type: none"> • Good hygiene and manufacturing practices including equipment cleaning and personnel hygiene. • Production sequence (produce package which have direct food contact first before the packages without direct food contact) • Control all microbiological, physical, chemical hazards when producing packages with direct food contact. • Machine setup for production of direct food contact. • Applying food safety standards
Purchase department	<ul style="list-style-type: none"> • Purchase orders for the needed raw material from suppliers with the best cost • Checking compliance 	<ul style="list-style-type: none"> • Coordinate with quality control to insure that regulations are compiled well.

Concluding remarks

The focus of this study was to assess the current process of corrugated packaging development at Company P (Sweden) from a food safety perspective, to identify what is lacking in the process to ensure that the requirements for direct food contact packaging are sufficiently considered in development projects, as well as to get a holistic view of food companies' and experts' opinions about using cardboard (corrugated and solid) in the food industry as a primary and secondary packaging.

There are more guidelines needed in the production of packaging intended for direct food contact in order to produce safer packages. Responsibilities were suggested to each department to help produce safer products. Different departments within the company are recommended to be more aware and to act based on these specific responsibilities. The company is recommended to also have increased awareness if the changes in responsibilities are to be implemented, as well as greater control of their revised functions or processes.

Each food product has specific packaging requirements. To help in identifying and addressing these requirements, a template for sales, logical diagram and system template for various departments were designed to facilitate and improve internal communication within the company. Additionally, the templates were constructed to help the packaging company in their development process, such as asking the appropriate questions to the customers, identifying the needs of each product, and sourcing the right material to be used for the packaging.

Recommendations for further research

After this study was done, through investigating and assessing the packaging development process at a packaging company from a food safety prospective, further research is needed to test different food products (inside solid and corrugated packaging) through the supply chain to identify more possible risks that can affect different physical chemical and microbiological hazards.

More rigorous studies are also needed to improve the developed tools (logic diagram and template), which have been created for the packaging companies in this research. Through this, food and packaging companies will be able to implement better procedures throughout the supply chain, from manufacturing until consumption, as well as in choosing the best possible packaging material which varies from one product to another.

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Lund, 2014

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1 Introduction

1.1 Background

1.1.1 The corrugated board industry

The corrugated board industry is considered the most used transportation packaging in the world. More than 70 % of all transported produce uses packages that are made from corrugated board (Irvine, 2011). Forty percent of corrugated packaging is used for packing food products, but only 4% of this is actually used in direct contact with foods while the rest is used as a secondary packaging (Irvine, 2011). The production of corrugated board is approximately 42 billion m² per year, a quantity enough to cover more than the area of Switzerland. About 40% of corrugated packaging is used to protect food products and helps minimize food waste (Fefco, 2014) (Fig 1). All retail stores have numerous shelves with packaging for almost all food products. Cardboards are widely used in food; however, only a small percentage is used for direct food contact, as shown in recent statistics; examples of these include pizza cartons or boxes for hamburgers or sandwiches (Fig 2). The examples stated could be considered high-risk applications due to the relatively high temperature of the food when initially packaged and the high fat content of the food products, which can contribute to faster migration rates of unwanted substances from the packaging to the food (Albu & Buculei, 2011).

Company P background

Company P is a leading European multinational paper-based packaging company producing corrugated packages. The company is present in many countries around Europe, with more than 20 000 employees. The company was established as a box-maker with paper, recycling and forestry operations.

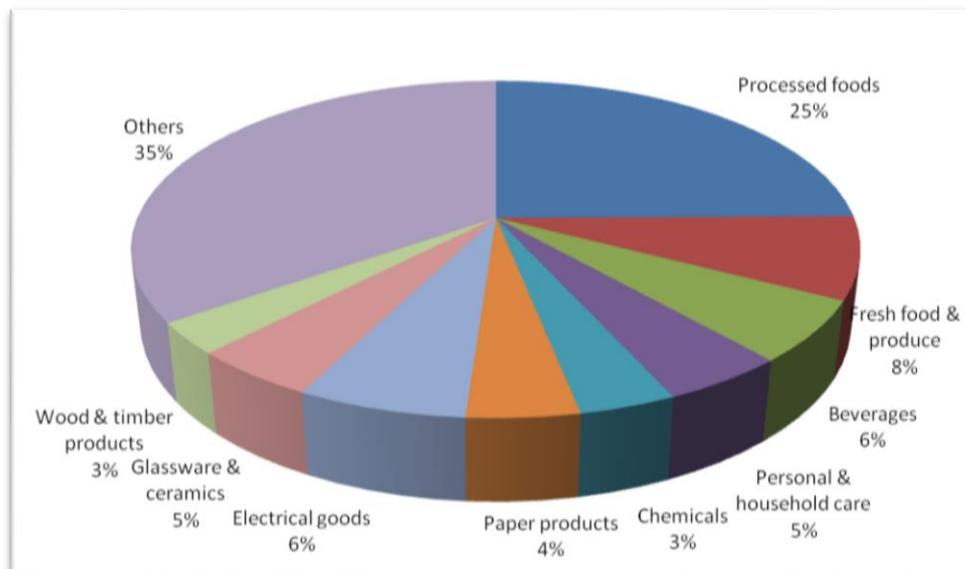


Figure 1: End-use markets for corrugated board in 2009, volume from Pira International, 2010



Figure 2: Samples for packaging with direct contact with food

1.1.2 Potential hazards in cardboard industry

A study showed that when customers asked whether producers of board had carried out Hazard Analysis and Critical Control Point (HACCP) studies, several producers did perform evaluations. The study also showed that there were some potential for microbiological, chemical and physical hazards (Bovee et al., 1997).

Hazards can occur in paper mills or packaging plants. In paper mills there can be microbiological (handling/storage, water circulation, starch and process environment) and physical (process environment) hazards, while in packaging plants, there can be microbiological (from storage, glues, packaging and process

environment), chemical (printing) and physical (from storage of products, packaging and process environment) hazards (Bovee et al., 1997). The EU legislation suggests that food business operators and food packaging industries should set in place a quality system like HACCP to ensure the safety of foodstuff (Bovee et al., 1997), and to ensure that all possible risks related to contamination of packaging materials are completely eliminated. As food safety is of utmost importance for the food industry, more studies are needed for packaging, especially when it is intended for direct contact with food products. Moreover, there is a need to ensure that there is no transfer of hazardous substance or contaminants from packaging to our daily food products.

1.2 Problem description

The problem of food safety and food security is an international concern. It is important that the package does not interact with the food and does not change the properties of the food product. The package should also prevent the growth of microorganisms.

In one study, tests were conducted on paper packaging made from virgin and recycled fibers. The results showed that virgin fibers exhibited low penetration of chemical substances to the packaged food product, whereas recycled paper has a very high contamination risk. Paper made from virgin fibers are usually refined using various sizing, dyeing agents and varnishes. Those substances have less effect on the packaged product than the packaging made from recovered fibers. In the case of recycled fibers, the main contaminants are aldehydes, alkanes, ketones, phthalates traces and amounts of heavy metals, besides the constituents of printing inks, sizing agents, and coatings (Parry & Aston, 2004 and Stepien, 2013). Recycled paper and paperboard products that are used in food packaging are made from recycled newspapers, milk cartons and magazines and then pulped with water and cleaned and de-inked with surfactants. Additionally, a number of chemicals such as inks, bleaching agents, and slimicides are used in production of recycled paper and paperboards (Honkalampi et al., 2010). Migration studies concluded “there is no report as to whether these compounds remain present in the final paper and paperboard products.” Although it is reported that ink ingredients remain present in recycled paper and paperboard (Castle et al., 1997).

Paper, carton, wood and metal are traditionally used materials in food packaging and are considered to be safe materials. Diffusion-controlled process is a process in which migration occurs from food packaging to foodstuff by chemical processes and reactions, including temperature of packaging, heat treatment, storage time and UV light exposure (Arvanitoyannis & Bosnea 2004). For example, printing may lead to

contamination of packed products (Lau & Wong, 2000). If the packaging used is made from inappropriate materials, it may pose a risk to the packed product, thus to human health (Baba et al., 1998 and Pocas & Hogg 2007).

The additives used in paper and paperboard food packaging are governed by national regulations. There are either regulations or recommendations in some individual member states of the European Union (EU), but there are no specific EU-harmonized directives or regulations on paper and board, rather than the general framework regulation No. (EC) 1935/2004. The central provision applying to all food contact materials is as follows:

“Materials and articles must be manufactured in compliance with good manufacturing practice so that, under their normal or foreseeable conditions of use, they do not transfer their constituents into foodstuffs in quantities which could either endanger human health or bring about an unacceptable change in the composition of the foodstuffs or deterioration in the organoleptic characteristics thereof” (EC 1935/2004).

It is still a challenge to demonstrate all known and unknown substances and to use the right material. There is a responsibility for the packaging manufacturer to ensure that boxes meet all the requirements of food safety and hygiene. Companies need to improve their system of choosing the appropriate material that can be used when food contact is the case. Another problem can be the ways of internal communication between different departments and work divisions inside the company (e.g., sales, design, purchase and production). Identification of whether the packaging will be used for direct food contact or not must be known at the early stages of packaging development. Consequently, if internal communication works properly within a company, the purchase department can source the appropriate raw material depending on the type of the food product, and the production department can be supplied with the right material.

1.3 Goal and purpose of the research

The main purpose of this thesis is to assess the current process of packaging development at Company P, Sweden, specifically from a food safety perspective, focusing on the following questions:

- (a) Does the process in the early stages identify whether the packaging to be developed is supposed to be used for direct food contact?

- (b) What is lacking in the process to assure that direct food contact requirements are sufficiently considered in development projects where food safety requirements apply?

To fulfill this purpose, the following sub-objectives have been defined:

- To design a template which can be used as a supportive tool to help designers and sales managers to ask the appropriate questions to the customer, before or during the project, to recognize if direct food contact is the case.

To explore the current system and give suggestions on how to improve the data collection and internal communication between different departments within the company (i.e., sales, design, purchase, production), in order to assure that the packaging meant for direct food contact fulfills the required food safety requirements (e.g., to assure that purchasing has sufficient information to source correct material for production).

1.4 Delimitation

The workload was adjusted to the time frame. The research focused on the corrugated industry of Company P, Sweden. Their current processes involved in packaging development and communications, from a food safety prospective, was observed. The master thesis was carried out for a total of 20 weeks.

The author divided his time between being present at Company P in Sweden or at IKDC at Lund University. The two locations were important as the insights from the company personnel were attained in the former and faculty resources were utilized in the latter. Every 4 to 5 weeks a meeting was set with the personnel in charge in the company and the academic supervisor where development of the project was discussed.

A limitation of this study was that most interviews were from Swedish companies and organizations, and as such, it did not show a global prospective. The views presented in the thesis might be applicable to the Swedish packaging industry context only. The selection of interviewees was achieved through the assistance of academic and industrial supervisors. Due to confidentiality issues and sensitivity of the topic, not all the formulated interview questions were answered completely. Due to the author's limitation in understanding the Swedish language, as well as the time limitation, not all acquired documents from the packaging company were utilized. Legislations and standards for cardboard packages have not been discussed in detail, as the focus was more toward their contribution on the packaging development process.

2 Methodology

2.1 Overview

In this chapter the researcher explains what had been done to conduct this study and what approaches and techniques were used to collect and analyze the data.

The first step towards defining Methodology is to take a deep look at the research problem, background and limitations in the previous section in this thesis. For the purpose of this study, a qualitative research method was used. The first part of the study included a literature review on related publications and official sources like doctoral dissertations, books, previous research, journals and official websites. Another type of data was collected through a qualitative approach through formulating semi-structured, open-ended questions for interviews, which were carried out with industry professionals from different departments within the packaging company like sales, design, purchase and production. Other interviews conducted were with people from different food companies that use cardboard packaging as a primary or secondary packaging, and experts and professors from Lund University, in order to have a better understanding of the bigger picture when it comes to packaging development. Interviews helped in expanding the knowledge of the existing packaging design process, as well as in gaining important insights that can help lead to a systematic approach of developing the template that can be used as a supportive tool in helping designers and sales managers to ask the right questions to the customers before or during the project, in the case of a packaging with direct food contact.

2.1.1 Qualitative research

The qualitative research approach has been used for this study. Qualitative research is a type of scientific research that uses a predefined set of procedures to answer questions, collects evidence and findings that were not determined in advance (Mack et al., 2011). The qualitative method investigates the *why* and *how* of decision making, not just the what, where, or when. Focused samples are more often used than large samples, and are used to produce findings that are applicable beyond the immediate boundaries of the study (Denzin & Lincoln, 2005).

The most common qualitative research methods used are the semi-structured methods such as in in-depth interviews and participant observation; each method is particularly suited for obtaining a specific type of data (Patton, 2002). In depth interviews were used in this research, as they are optimal for collecting data on individuals like perspectives and experiences; in addition, this method is used particularly when sensitive and important topics are being explored. While participant observation is appropriate for collecting data on naturally occurring behaviors in their usual contexts (Denzin & Lincoln 2005 and Albu & Buculei, 2011), the method of semi-structured qualitative interviews was also chosen because this gives the respondents the opportunity to answer freely, reasoning relevant aspects for the investigation.

2.2 Data collection

Data collection covers the answers of each interviewee, and also includes documents that have been reviewed, and observations. The primary data has been collected from the transcribed interviews and observations while the secondary data was from different sources like reports, PhD dissertations, and scientific articles.

Different sources were used to compare and contrast with the research findings. The findings from the interviews were summarized and integrated with the relevant findings from the reviewed literature in order to have a better understanding of the situation. Not all the formulated questions have been answered completely by the interviewees due to some confidentiality issues.

In order to increase the reliability of a study, triangulation technique was used (Golafshani, 2003), Triangulation was done through collecting data from different sources such as:

- 1) Interviews with packaging actors, food manufacturers, and professors and experts in the field of food and packaging.
- 2) Review of legislations and related publications in the field of food packaging and food contact materials.

Also, other sources of information such as relevant articles, journals, official websites and company reposts were used. Triangulation involves the usage of multiple sources of data and different perspectives (Maxwell, 1996). Lastly, in order to get a higher degree of validity, face-to-face interviews, with questions under supervision, were conducted to help the researcher to evaluate and analyze the respondent's answers.

2.2.1 Interviews

Semi structured open ended questions have been formulated prior to the interviews. The main questions started with “what,” “how” and “why” in order to let each respondent choose his own words to answer each questions.

For the purpose of the study, the author used face-to-face interviewees in a comfortable atmosphere. One of the advantages of this method is that the author can evaluate the validity of a respondent’s answers since he can visually observe them (e.g., for physical cues and body language) in person. During each interview the sequence of the questions was not rigidly followed to be able to allow for new or follow-up questions as needed throughout the flow of the conversation.

As mentioned, experts and professionals were interviewed for this study. The respondents were selected based on their expertise in the field; there was also help from the industrial supervisor at the packaging company during the selection process of possible interviewees with knowledge in each field. The interview questions that were used are listed in the appendix.

In order to understand the packaging development process, the first interviewees were done with experts from the main departments involved in the packaging development process at Company P. The second set of interviews were conducted with 3 different food companies that use the cardboard packaging as a primary or as a secondary packaging, and their opinions about the safety of cardboard packages in the food industry were gathered. Lastly, the third set of interviews was conducted with experts and researchers in the field of food packaging and microbiology as illustrated in the tables below.

Table 1 Interviews in Company P with different departments involved in the packaging development process

Code	Expert	Respondent Position Title	Years of experience
P1	Purchase	Purchase & Logistic Manager	10 years
D1	Design	Design & Innovation Manager	11 years
S1	Sales	Regional Sales Manager	14 years
Pr1	Production	Printing Manager	14 years

Table 2 Interviews with packaging experts from food companies

Code	Type of product	Number of employees within the company	Respondent position title	Years of experience	Type of primary package	Type of secondary package
(F1)	Frozen products	6000 employees	Packaging developer	19 years	Plastic bags for frozen products	Corrugated board with internal coating
(F2)	Baked products	1,400 employees	Purchasing manager packaging	15 years	Plastic bags	Recycled corrugated board
(F3)	Shelf products and frozen products	1,500 employees	Packaging manager	12 years	Solid, corrugated (recycled, virgin), plastic	Recycled corrugated board

Table 3 Interviews with experts from the academe

Researcher code	Respondent position title	Years of experience	Department	Experience in
R1	PhD	36 years	Packaging logistics department	Packaging and food industry
R2	PhD	35 years	Packaging logistics department	Corrugated packaging industry
R3	PhD, Associate Professor	7 years	Applied microbiology	Food microbiology and food packaging

2.2.2 Setup interviews

The interviews were arranged through emails or telephone calls and questions were formulated before the interviews. A copy of the questions was sent to each interviewee prior to the actual interview. To document the interview better, interviewees were asked for their permission for the researcher to record the audio; this allows for a better conversation because the researcher is completely focused on the interviewee as he or she responds, and there is also more attention towards the body language of the respondent.

The length of each interview was approximately 50 minutes, on average. At each interview, the researcher started by explaining to the interviewees the purpose of the interview and gave a short presentation of the project and the research questions; also, issues regarding confidentiality have been discussed in order to make them

more comfortable. Depending on the respondent's backgrounds, the questions were also slightly modified. Chronological order and time spent in each question differed from one interviewee to another. At the end of each interview, the respondents were asked if they would like to add any further information.

2.2.3 Data analysis

As a tool for data analysis, thematic analysis was used. Thematic analysis is a vital method for identifying and analyzing patterns in qualitative data; it can work with any size of data sets and wide range of research questions (Braun & Clarke 2006). The interview transcripts were categorized into themes and analyzed according to the research objectives and related literature. To categorize the interview questions and content, the different stages, as seen in the table below (Braun & Clarke 2006), were followed.

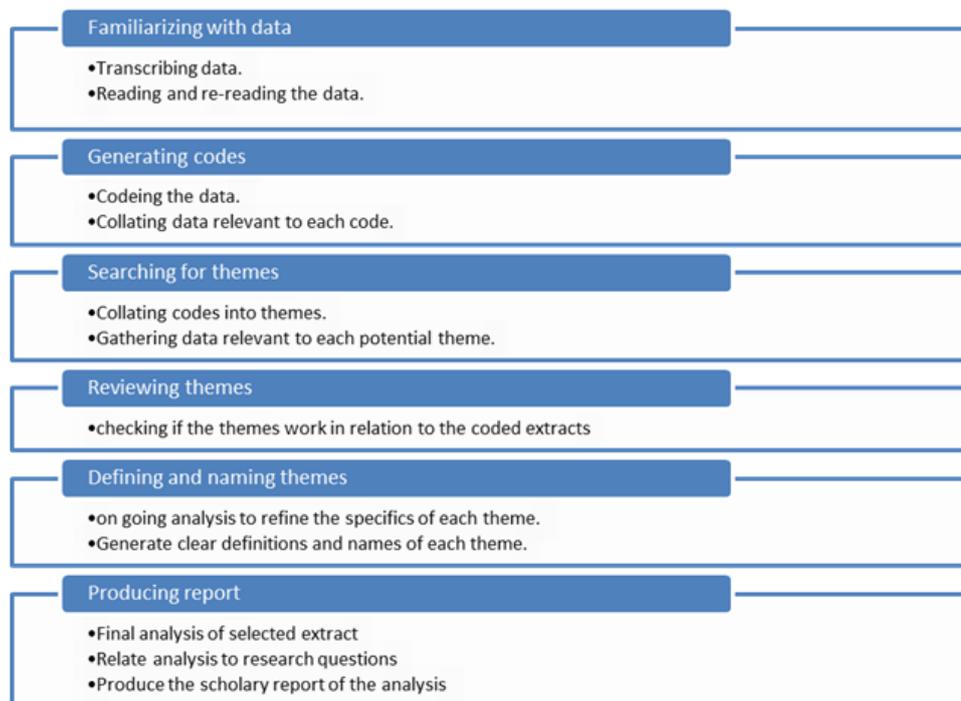


Figure 3: Phases of thematic analysis (Braun et al, 2006, p. 87)

The data collected from the interviews with the people in the packaging company, the food companies, and the researchers were summarized and the author sought for common answers between different interviewed actors. Then, the researcher

compared these to the reviewed literature to be able to identify what is being done by the company versus what was not being fulfilled in order to recommend any areas for improvements, and to be able to somehow obtain a view of “the bigger picture” of the current situation in the industry.

An inductive approach was applied in this research. The inductive method means that the themes are linked to the data because assumptions are data-driven but without getting free from the theoretical epistemological responsibilities (Richard B.1998).

The author tried to categorize interview questions into four main topics which are: (1) responsibility of each department in the packaging development process, (2) safety of cardboards for direct food contact, (3) usage of virgin or recycled material for food packaging, and (4) legislations related to cardboard packaging. Each category of interviewees (i.e., packaging company, food company, food/packaging expert) had a common list of questions, but within each category, some questions had been slightly modified depending on the specific background and knowledge of the person being interviewed.

After transcribing each recorded interview into text and getting familiar with the content of the data, the author focused in analyzing the data. In order to gain meaningful parts of data as it relates to the research questions, the researcher tried to identify common patterns in the respondents’ answers and categorized them into unifying themes. These themes that were found after analysis were: (1) considerations for using recycled materials for food contact products, (2) harmonized legislations, (3) unique selling point, and (4) areas for improvement in the packaging company (Company P). Finally the findings were compared with data coming from literature.

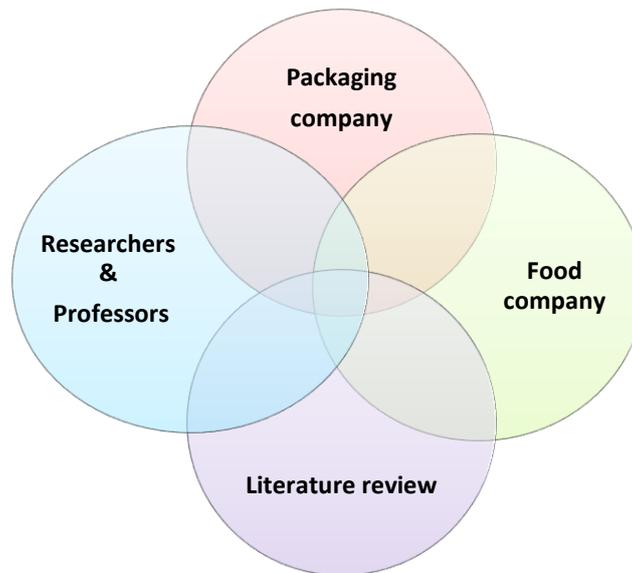


Figure 4: Analysis of the interview results

A simplification of how the different results were analyzed can be seen in the venn diagram in Figure 4. Transcripts of the personal opinions and factual information that were answered in the interviews with the three categories of respondents (the packaging company, food companies, researchers and professors) are the data that were processed through thematic analysis. By viewing the interview data through the lenses of the four final themes, there was a more systematic approach of collating them with the relevant research findings obtained from the literature review. With this approach and with the researcher's own insights in the analysis, the research objectives were fulfilled.

3 Frame of reference

3.1 Food packaging

Packaging has vital functions throughout the supply chain. The primary function of packaging is to protect the product during transportation and handling, to survive against chemical and physical damages, thus preserving food. Packaging is also important to display, sell, promote and inform the customers about certain product characteristics. Packaging can also influence the purchasing decisions of customers (Schueneman, 2014).

3.1.1 Corrugated boards and food products

Paperboard boxes are traditionally used as a secondary packaging but could be used as primary package with liner on the inside (e.g. cereal). In some cases it can also be used without a liner in the case of dried food products (e.g., pasta and rice) (FEFCO, 2014).

Many food products are packed in corrugated boxes. Corrugated boxes need to be protected from humidity, direct sunlight and heat (Pastorelli et al., 2008). For frozen products or products that are high in moisture, a wax-coated cardboard box is used to prevent moisture loss. If air ventilation and circulation is required, the boxes should have pre-cut holes. To increase the level of protection, materials such as paper pads and wrappings are traditionally added to corrugated carton (Stepien, 2013).

Table 4: Main types of cardboards used as food packaging (Albu & Buculei, 2011)

➤ Cardboard type	➤ Description:
➤ White board	➤ Several thin layers of not chemically bleached pulp, used as the inner layer of a carton, used for direct food contact.
➤ Solid board	➤ Several layers of sulphate bleached boards to give strength, can be laminated with polyethylene for liquid products like juices and milk.
➤ Chipboard	➤ Recycled paper contains impurities from the original paper used for outer packaging, low in price and not appropriate for direct food contact.
➤ Fiberboard	➤ Used for shipping bulk and retail food products, can be solid or corrugated, not appropriate for direct foods contact. ➤ Solid type consists of inner white board layer and outer

	<p>Kraft layer. Good support and protection for product.</p> <ul style="list-style-type: none"> ➤ Corrugated type: upper and lower layers of Kraft paper with a central fluting material to reduce crushing and damages.
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3.1.2 Advantages and disadvantages of corrugated board and paper materials used for fresh and processed foods

Corrugated and solid boards are widely used in food packaging. Corrugated board is not mainly used for food contact. On the other hand, solid board is used for direct food contact (Schueneman, 2014).

Corrugated boards are recyclable, cheap, and resistant to crashing and can be easily printed. However, mechanical properties of this type of packaging can change due to humidity and temperature, although the issue can be solved by lamination with other material (e.g. plastic), or by using wax-coated boxes (Motarjemi & Lelieveld 2014).

Paper is easy to shape and store and can be recycled (Schueneman, 2014). However, it has high water absorption rates and is a poor barrier to liquids, oils and fats. Coating is fundamental if paper is meant to come in contact with fresh food. Using a functional barrier (e.g. PE-coated paper) can prevent any mass transfer between the food and the package. On the food contact side, it can give the paper material a resistance to humidity and fat adsorption, which leads to better preservation for food content (Motarjemi & Lelieveld 2014).

3.2 Food packaging and food safety

Food package manufacturing, like other types of processes throughout the food supply chain, can be exposed to physical, chemical or microbiological hazards. Such hazards can produce contamination to food once consumed; contaminated products can cause negative effects on consumer health (Motarjemi & Lelieveld 2014). Legislation has been introduced to control and prevent the migration of chemicals from packaging to food in the case of direct food contact. Food contact material should comply with specific regulations and Good Manufacturing Practices (GMP). According to legislations, packages that have direct food contact should be traceable from manufacturing to distribution. Food contact materials should follow the limits of migration and comply with specific regulations (CEPI, 2011).

Additionally, many countries are gearing towards sustainability. Nowadays packaging companies are also pushed to be more environmentally friendly to improve their image to their customers. In response to this, packaging companies use recycled materials. A recycled material, however, can pose some risks toward food

safety (Pocas & Hogg 2007 and Jamnicki et al., 2012). A recent governmental report launched by Swiss scientists found large quantities of mineral oils above the accepted limits in recycled cardboard which was used in packing of food products like rice, pasta and cereals (Biedermann et al., 2011).

3.2.1 Types of hazards and food safety management

The safety at any point in the chain from producer to consumer is a global concern. Food safety hazards may be introduced at any stage, therefore adequate control throughout the production chain is essential. In 2008 ISO published that the consumers can become seriously ill from unsafe food, and corrective actions can be costly for industries (Stepien, 2013). There is rising awareness of potential hazards throughout the entire food chain; therefore, food safety is the responsibility of all actors in the food supply chain.

There are three main types of hazards that can affect the safety of food and cause foodborne illness. Every step in the food supply chain has the potential to affect the safety of food (Berry, 2010).

The main types of hazards are physical, biological and chemical hazards. These hazards should be identified and controlled by each actor in the food industry and packaging industry (Hemminger, 2000).

Physical hazards: These occur when a foreign object gets into the food product accidentally. Physical contaminants are easily seen and reported by customers. Physical contaminants include dirt, insects, part of packaging inside the product, glass shreds from damaged UV lights or metal fragments from equipment. Proactive measures can limit and control such kind of hazards to occur. Such contaminants should be avoided through a feasible quality assurance program and through creation of Clean In Place (CIP) systems (Motarjemi & Lelieveld 2014).

Chemical hazards: These include harmful chemicals that can get into the food during manufacturing processes or through direct contact with the package and the foodstuff. Chemical contaminants such as pesticides, detergents can be caused by malfunctioning of chemical handling devices. Presence of cleaning agents can be also due to chemical substances present in the recycled package that have direct food contact, that contain heavy metals and mineral oils that are above the accepted limits (Irvine, 2011).

Biological hazards: This includes microorganisms in contaminated food, which can cause foodborne illnesses. Harmful microorganisms are called pathogens, which can come and spread through food from different sources:

- 1) Through people: People can spread contaminants through coughing and sneezing and touching food packaging with unclean hands.
- 2) Pests such as rodents and flies can carry and spread diseases. These can also contaminate the package or packaging machine, food and food areas.
- 3) Equipment: Unsanitary equipment and facilities may also spread harmful microorganisms to food then people (Motarjemi & Lelieveld, 2014).

Understanding the possible microbiological, physical, chemical hazards through the process of paper board manufacturing is essential to identify the Critical Control Points (CCP) in order to control the process and produce packages which can be safe for direct food contact (Motarjemi & Lelieveld, 2014).

The paper and paperboards are treated to a temperature from 80 to 120°C through manufacturing. This improves the microbiological quality of the final product; however, this temperature is not sufficient to kill spore-forming bacteria occurring in the pulp (Parry & Aston 2004).

It is the responsibility of each actor in the packaging companies and food industries to produce and handle safe packaging; this can be done through good communication between different actors and departments in the packaging and food industries. One way this can be done is by certifying, from an early stage of development, that the correct packaging material will be used—one that will properly address the safety requirements of the food product, which depends on its composition and characteristics. As discussed earlier, one of the fundamental tasks of any food packaging is to prevent unwanted substances to be transferred into the food that it is supposed to protect and contain.

3.2.2 Migration

Migration is the process in which some chemical compounds or some substances are transferred from the packaging into the food product.

Table 5: Different ways of Migration in cardboard packages. Source *Printing Inks for Food Packaging (Kim & Gilbert 1989 and Stehlin, 2011)*.

Migration	<ul style="list-style-type: none"> • Packaging component with low molecular weight, like inks and coatings, can pass inside food through migration.
Invisible substance	<ul style="list-style-type: none"> • This can occur through the packaging production process. Stacking causes the printed side to come in contact with the other side (the food contact side). This can lead to

	potential colorless substances and invisible inks to transfer to the food contact side, and therefore can be transferred to the food.
Head space	<ul style="list-style-type: none"> This can happen between the food and packaging without any direct contact. Through the gas space (headspace), the volatile air enclosed between the product and the packaging can affect the organoleptic properties of the food stuff.

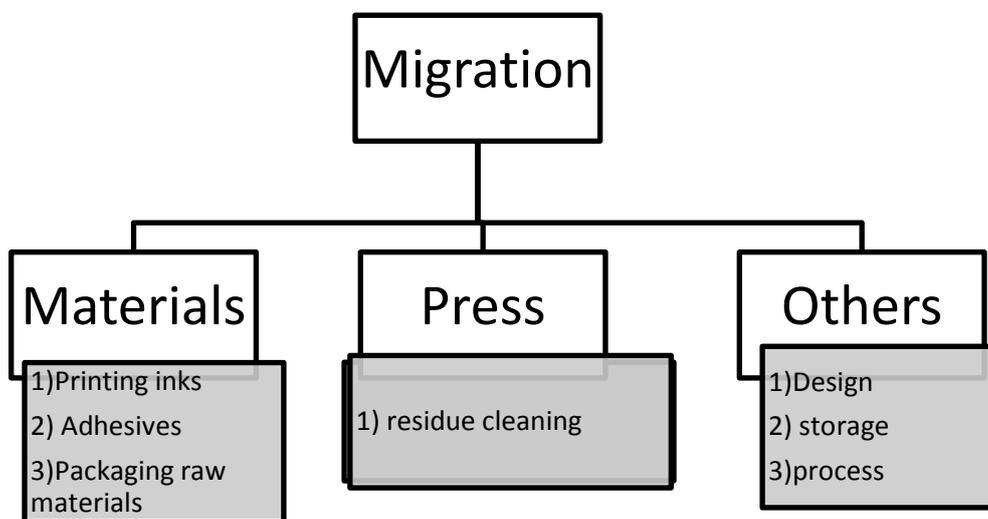


Figure 5: Factors that impact migration

Table 6. Factors impact migration (summarized from Stehlin, 2011)

Inks	<ul style="list-style-type: none"> Low migration inks can be used as food packaging. Inks used in food packaging should be free from any contaminants
Adhesives	<ul style="list-style-type: none"> It is important to choose the right adhesives; there is also a possibility for migration to occur from adhesive to food
Material used	<ul style="list-style-type: none"> Must comply with food safety requirements for direct food contact and printing process should not affect the organoleptic properties.
Residues	<ul style="list-style-type: none"> It is important to check that there is no ink residue from non-food packaging inks in the press; a check needs to be done in the roller and other objects which the food packaging may have contact with.
Packaging	<ul style="list-style-type: none"> Selection of right material. The amount of applied ink to

design	surface must be considered for migration risk assessment.
Storage	<ul style="list-style-type: none"> • The storage conditions can influence rates of migration; temperature and moisture can have negative effects on the organoleptic properties.
Processes	<ul style="list-style-type: none"> • Information exchange throughout the process will facilitate assessing of potential migration risks. Also, the recall of defective products, if there are any, is necessary to be able to identify responsibility for the cause of the defect. Everything should be documented from raw material to the packaged product.

3.2.3 Functional and non-functional barriers source

A barrier is a layer within food contact materials preventing the migration of substances from one side to another. Paperboards are considered nonfunctional barriers, as printing inks with low molecular components and mineral oil can migrate easily to the food products (Motarjemi & Lelieveld, 2014).

Table 7: Barriers used in the cardboards industry

Oriented polypropylene (OPP)	<ul style="list-style-type: none"> • These films have a variety of uses; can be a good barrier against water but can't prevent mineral oils or printing inks. Also, the temperature can affect the amount of substances that migrate.
Aluminum foils	<ul style="list-style-type: none"> • These are thicker than 7 µm and can be considered as functional barrier if an eye has been kept for the invisible substances and its contact with ink from the side of food product.

3.3 Research studies on food packaging and migration

In 2008, researchers from Milan University found that some chemicals are transferred from packaging to food, such as ink traces, glues, paints, and other chemical substances in the pizza boxes. They have explained that this phenomenon is due to the high temperature inside the boxes, which is approximately 65°C (Bononi & Tateo 2009).

Another study in Romania was conducted using a cardboard box used for pizza packaging. The influence of the cardboard package on the quality of the food product showed that the direct food contact between the product and the package leads to the

migration process (Albu & Buculei, 2011). The components of the package may be dangerous when exposed to high rates of temperature and other circumstances, and as a result can affect the chemical and sensory properties of foodstuffs (Poulter, 2011). The results showed that there is an interaction between packaging materials and food products, as the migration process starts on the packaging, and some of these materials affect the quality characteristics of the pizza and increases the risk related to consumption of the pizza packed in the cardboard boxes. The research stated that after few hours of food packing, all food properties have been changed due to the direct migration of components from the package to the product (Albu & Buculei, 2011).

Several studies have been conducted in the field of food safety about substance migration from packages to foodstuffs, and they found that migration processes occur in both directions between the food and the package; this was very dangerous as this may affect food quality and can cause food contamination.



Figure 6: Illustrates the condition of pizza packaging before and after consumption

The images above show pizza after serving and after 30 minutes when it was consumed. It is visibly clear from the image the amount of fats from the pizza that was transferred to the package in only 30 minutes.

Ahvenainen (2007), in his research, stated that packaging used for pizza products should limit oxygen transfer, protect the product against light, and maintain humidity inside the boxes. Barnes (2007) stated that the cardboard boxes should not allow the

transfer of poisonous or dangerous materials to food products as to not affect the consumer's health; also, limits for the presence of heavy metal compounds should be set in place.

The Joint Food and Agriculture Organization of the United Nations/World Health Organization Expert Committee on Food Additives (JECFA), stated that there is a limit of 0.6 mg/kg for the migration of mineral oil saturated hydrocarbons (MOSH).

Another study was conducted in Switzerland about migration of mineral oil into noodles from recycled fibers in the paperboard box and the corrugated board. In this study, (Biedermann et al., 2011) it was found that noodles in its structure contain 205 mg/kg MOSH before packaging due to other sources of contaminants. The study further stated that packaging materials are not the only relevant source of mineral oil, which makes it quite difficult to identify the main source of contamination because as time passes throughout the shelf life, the migration process continue to happen (Biedermann et al., 2011). The same research showed that in examining the noodles after 65 days with a product with 2 years shelf life, they found that the transport box of corrugated board contaminated the bottom packs in the box with 6.1 mg/kg with mineral oil saturated hydrocarbons (MOSH). This research also found that the printing ink containing 3g/kg contaminated the taglioline with 0.6 mg/kg MOSH. As the research also stated, the migration of compounds from transport boxes is lower than that from recycled paperboard primary packaging but likely to exceed 0.6 mg/kg in a wide range of products, frequently up to 10 times (Biedermann et al., 2011).

The Official Food Control Authority of the Canton of Zurich stated that “packaging is not the only way food contamination can occur and is not the only source of mineral oils,” neither for noodles nor for other food stuffs. There are many sources of food contaminants that are not identified yet. (Biedermann et al., 2011). “In 2009, the German Federal Institute for Risk Assessment (BfR) issued a warning regarding the direct contact of large surface dry foods with recycled cardboard. Food packaging is subject to EU-Regulation 1935/2004 and must not be harmful to consumer health. The implementation of separate maximum levels for Mineral Oil Saturated Hydrocarbon (MOSH) and Mineral Oil Aromatic Hydrocarbon (MOAH) originating from food packaging manufactured using recycled paper is currently under discussion in Germany.”

3.4 Recycled food packaging

More than half of the cardboard used in Europe is made from recycled materials, and this phenomenon is widely accepted in Europe (Irvine, 2011). Part of the reason is that most of the companies are gearing to be environmentally friendly to improve their image to their customers. Recycled cardboard cartons which can package

different food product types seem to be environmentally friendly, but on the other hand, some researchers found that these cardboard boxes and containers can contain dangerous compounds which migrate from packages to food products, causing some harmful effects on human health. In Germany and Switzerland, inks used in newspapers found that the levels of leaching of substances from packages to products is up to 100 times the agreed safe limits in products sold in supermarkets (Parigoridi et al., 2010).

As food packaging, food safety, and consumer health are very important issues linked together strongly, food manufacturers and researchers tend to search for an alternative packaging in order to be safe and environmentally friendly for future use. Virgin boards, which are made from trees, can be an alternative, but it has a high cost. Dr. Grob stated that “using a different material will not prevent the possible risk of contaminations, as contamination can occur from transportation or machinery, which can have dangerous levels of mineral oils, which can transfer to the package then afterwards to the food.”

Many food companies that produce functional foods and healthy products are working together with their own packaging suppliers to find new packaging that will contain significantly lower levels of mineral oils. They are looking at a process to reduce the levels of mineral oils to the accepted guidelines (Poulter, 2011).

For example, Nestle uses plastic films around their cereals in its boxes, and declared that they do not use recycled fibers in their cereal boxes. Some tests have found that mineral oils could even leak through plastic inner packaging. Jordans (a British company that produce cereals similar to muesli) is looking for alternative liners and working on having lower levels of mineral oil on their packages (Poulter, 2011).

3.5 Internal and external communication in a packaging development process

3.5.1 Internal communication between main departments

Various departments in packaging companies are interconnected around the main function, which is product development. The sales department is responsible for connecting and attracting new customers, which is why marketing is often integrated with the responsibility of the sales department. The sales department communicates with potential customers; the product is marketed through a business-to-business market communication through ‘face-to-face interaction’ (Rowley, 1998). The product development department designs the packages based on customer requirements and needs, or innovates the existing package to form potential

customers. Safety, legal and purchasing teams are also involved in the process to reflect the interest from outside (Gawek et al., 2007).

3.5.2 External communications

External communication is communication between the packaging company (as a whole) represented by the sales department and the client (e.g. Food companies)

Successful management and communication can bring more customers to the company, customer communications are based on three main stages defined by Rowley (1998): 1) Cognitive stage is when potential clients notice the products and become aware of the other offers. 2) Affective stage is when customers form their attitude towards the products. The first two stages, affect the last stage which is 3) behavior stage, which is often related to a purchasing of the product.

3.6 Food contact materials and legislations

Packaging materials that have direct contact with food have to be developed based on certain requirements. To help ensure the safety and hygienic manufacture of packaging, there are few regulations that are concerned with corrugated food packaging, paper, and packages that deal with food and have direct contact with food; they are summarized below.

Some food safety regulations have been introduced under control of the government upon the request of customers for food safety reasons, such as the regulation on materials and articles in contact with food (EU Regulation 1935/2004). Packaging materials that are in direct contact with food that are used to protect and transport any food substances must comply with the existing regulations, such as the regulation on materials and articles in contact with food (EU Regulation 1935/2004).

3.6.1 Legislations that apply to Company P:

Regulation EC 1935/2004 covers all types of packaging and materials that are used in contact with food directly or indirectly, and other things like labels, adhesives and inks. Regulation EC 1935/2004 deals with food safety issues and general requirements for all food contact materials, as any changes in food composition are forbidden. It deals transparently with consumers regarding labeling and advertisement in order to achieve the guaranteed level of protection of human health.

Materials that are in direct contact to food should have been made in accordance with good manufacturing practices so that nothing could be transferred from the packages to the food upon contact, so as not to affect human health or make any changes in

food composition. Materials and packages in direct contact with food must not cause any chemical reactions that would change the chemical composition or the organoleptic properties of food such as taste, appearance or texture.

Regulation includes groups of materials and articles in Annex I of the regulation in which specific measures may be needed. Some of those are: adhesives, cork, glass, plastic materials, paper and cardboard, printing inks, waxes, varnishing and coatings, etc. The regulation does not include: covering or coating materials, such as materials that cover cheese rinds, prepared meat products or fruit.

3.6.2 Good manufacturing practice for materials and articles intended to come in contact with food regulation EC 2023/2006

A quality control system following the detailed manufacturing regulations should be established in manufacturers in order to control the processes involving printing inks and material control for all the materials which are in direct contact with food (such as paper and cardboard, or those which could transfer their constituents or substances to food, for example inks and adhesives). All lists of materials are mentioned in Annex 1 Regulation (EC) No 1935/2004.



Manufacturers should create and maintain documents concerning their specific products and production process because it is important for food and consumer safety. This regulation includes a section for packaging manufacturers to create a better quality assurance system for competent authorities at their request.

Good Manufacturing Practice (GMP) was launched by the European Federation of Corrugated Board Manufacturers (FEFCO) and the European Solid Board Organization (ESBO), due to customers' demand of transparency in food safety and hygiene in materials and supplies (in addition, to categorical qualities such as recyclability, strength and lightness). As the GMP covers the manufacturing of packages, it is also concerned in assuring that boxes meet all the requested levels and fields of quality, safety and hygiene.



GMP is used to have a total control system all over the manufacturing plants in order to fulfill the requirements of the EU regulations 1935/2004 for food contact materials. As GMP covers the manufacturing of packaging composed of corrugated and solid board materials, it ascertains that from purchasing of raw materials until the end, process quality parameters, motorization, tractability and hygiene are managed.

Ultimately, packaging companies apply the GMP to be able to guarantee to their customers that they produce packages that are safe.

3.6.3 Prerequisite PAS: 223

“The Pre-requisite program requirements apply to corrugated packaging manufacturers, regardless of size or complexity, as well as to all who are involved in the manufacturing step of the food chain.” The PAS: 223 include information on a general level about the food packaging manufacturing setup. The main points are included in the table below.

Table 8 .Food packaging material manufacturing source (PAS223:2011)

1) Establishments
2) Layout and workspace
3) Utilities
4) Waste
5) Equipment suitability and
6) Maintenance
7) Purchased materials and services
8) Contamination and migration
9) Cleaning
10) Pest control
11) Personnel hygiene and facilities
12) Rework
13) Withdrawal procedures
14) Storage and transport
15) Food packaging information and
16) Consumer awareness

Product development process and prerequisite

Packaging companies are required to follow the EU regulations, while cardboard packaging prerequisites (PAS: 223) are not mandatory. Each company can choose their own way to assure the safety of their products. When a food company seeks for a new packaging supplier, the most important thing is to build trust. Packaging suppliers apply the prerequisites as proof to food companies that their packages are safe and that the entire manufacturing process was guided with specific measures that assure product safety. That also gives a better image of the company, which may result in increased confidence between food companies and their suppliers (packaging company).

The author believes that there is still a need for the authorities to support packaging companies with more detailed prerequisites, as the existing ones are only provided on a general level.

3.7 Summary of the frame of references (conclusion)

Based on literature, there are two main types of communication in a packaging company. Internal communication (within the packaging company) is communication between the main departments involved in a packaging development process. External communication (business-to-business) is communication between the sales representatives and the customer (the food company). These kinds of communication are done with the aim of attracting new customers (or growing the business with existing ones) and to understand the customer needs in order to fulfill them.

In order to produce safe packaging for food, it is important to understand the main types of hazards involved in packaging manufacturing, and these including physical, chemical, and biological hazards. These hazards should be identified and controlled by the actors in the food and packaging industries.

In the case of packages made from recycled material, an important problem comes from the presence of mineral oils and inks that could potentially migrate to the food, whether this is directly or indirectly in contact with the packaging. Few packaging companies have started to develop packages with functional barriers to avoid these chemicals from migrating to food (Cimpeanu, 2014).

Migration is the movement of atoms or molecules from the package to the food. It is important to understand that migration does not only occur due to direct contact but also due to volatilization of molecules that would then be free to travel to other parts of the packaging, and also ending up in the food. Migration levels can increase due to different factors, such as temperature, surface/area contact ratio, chemical properties of the food in contact, acidity, content of fat, etc. A food contact material can be safe to use for certain applications but not for others; therefore, it should be demonstrated that the food contact material is adequate and compliant for the intended application.

The EU legislations for cardboards are not very conclusive. The EU does not have harmonized legislation regarding the use of paper and cardboard for direct food contact (Biedermann et al., 2011). Due to this lack of resources, the EU commission does not want to regulate recycled paper materials (Biedermann et al., 2011). The main regulation 1935/2004, which applies to the cardboard industry, is also known as the food contact materials framework regulation, which sets out a series of requirements for all food contact materials. Cardboard, whether solid or corrugate, that is used in food contact material applications must therefore comply with the mentioned requirements. In addition to these “general rules,” food contact materials need to comply with regulation 2023/2006 (the GMP Regulation) on good manufacturing practices.

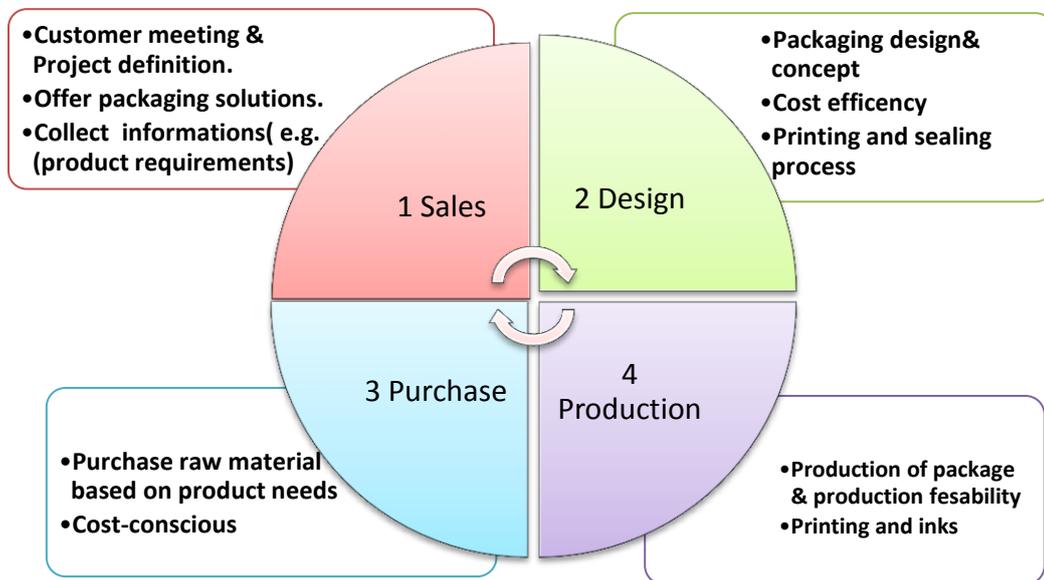
It is the responsibility of the company placing a food contact material or a food product on the market to make sure that the product is safe and that it complies with all the applicable legislations. This means that in the case of companies that produce food products, the responsibility is shared with the suppliers of the packaging, who then will have to make sure that their product (the package) is compliant.

4 Results

The results chapter presents the findings of interviews with professionals within the packaging industry, food companies, experts and professors in the field. The results of the interviews and the theoretical framework were used to investigate the current situation, and were then used to develop a template that shall help the sales and design departments to ask the right questions to their customers in the case of food-contact cardboard packaging. A system template was also designed for the sales department, wherein they can add their inputs into the system, which will also be used later on by the other departments involved in the product development process. The system template was also designed with the aim of improving the internal communication within the packaging company.

4.1 New packaging development process in a packaging company.

Figure 7: Main departments and their responsibilities in the packaging development process



Q1 How is each department involved in the packaging development process?

Sales: According to interviewees the process starts with the sales department. Sales department is the first department responsible for project definition in the new packaging development process. Sales representatives meet the customers and discuss with them their needs and what could be the best packaging solution for them. Each customer has a product with specific needs and requirements. A lot of issues are specified when a project is defined. Sales gather almost all customer inputs, from product application, product/packaging requirement, dimensions, functionality, appearance and secondary production requirements like printing and labeling. Sales representatives usually should have the knowledge to recommend which materials can be used for each product and which factory or line can produce this packaging. Sales department also provides the available options that the packaging company can offer to their customers. For example, a product which has a secondary package for bottles, cans or toothpaste have different needs than products which will be used directly in the corrugated boards as a primary packaging (e.g. pizza) in terms of protection and safety. A primary package for a food product has different requirements than that of secondary package, and it is also different for a frozen product than that of secondary packaging, for instance, in case of bottles of beer. After the sales representative collect the information from customers, it goes to an encoder, then all the collected data is added to the system. For the production of non-food products or food products with or without direct contact, the sales representative asks the customers for their needs and suggestions for materials that can be used, or if they have more needs for product protection.

The sales representative mentioned that there might be a need to design a specific checklist for sales to ask food manufacturers more appropriate questions, as different types of food products have different needs.

Design: The role of the design and innovation centre in packaging development is to design a package by looking at the needs of each product and focusing on the responsibility factors like safety and cost efficiency. Corrugated board design is the process of matching many factors like performance requirements with physical requirements to provide product protection, while controlling the total cost, to meet the end user requirements. Designers are responsible for controlling the strength, lightness, recyclability, and durability of the boxes. They are also responsible for many decisions like producing packaging concepts, graphic design process, the design printing process, and the sealing process. Physics is very important in designing the weight, size, proportion, and also deciding if it is a fragile product, a product that melts in room temperature, or a product that needs to be chilled. Depending on all those factors, a designer starts to develop a package.

The type of cardboards to use is important for designing a package for either food or non-food applications. Additionally, if the package will have direct food contact, the paper type on the inside should be approved as safe to use.

Purchase: At Company P, purchase gets most of the information from the system (internal communication) or directly from sales. Purchase orders the material based on the customer requirements; in most cases, customers do not recommend a specific material. The purchase manager mentioned in the interview that the department is not involved directly in the new packaging development process except if a special material is needed which they do not know about. In the case of food products, there is always a primary package that protects the product, and the corrugated box is normally used as a secondary packaging. The purchase manager mentioned that in case of direct food contact, a Kraft liner should be used, not a recycled material.

Production: Production is involved at early stage in collaboration with Design & Innovation Centre for the printing and appearance. In some cases, the production can have involvement with the sales department to check if the requirements of the customers can be met, or if the existing facility will or will not be able to produce a certain product.

During the interview, the production manager mentioned that “knowing if the product has direct food contact or not is defined in the beginning of the project.” In that case the food manufacturer asks the packaging company to add a special varnish, and use a Kraft liner, which is accepted for direct food contact. Company P has only one product at the moment that has direct food contact for a bread manufacturer. A special varnish is coated inside the box for protection from contaminants. The production manager also mentioned “it [varnish] is safe because the product has low water content, which means less risk for migration and contamination.”

There are no different equipment set-ups done in the plant for food product (with or without direct contact) or non-food product applications. The ink used is a safe, water based ink that is licensed from an ink supplier. The ink is applied on the outer part of the packaging only so it is expected not to affect the product; as such, the process is clean.

Based on the author’s understanding, sales, design and production have a follow up communication and involvement in the new packaging development and have a close communication with customers to identify the project and their customer needs for different products. All actors agreed that it would be useful if a checklist can be used

when communicating with food manufacturers, to be able to ask more specific and appropriate questions to them.

4.1.1 Current processes for development of food contact packaging

Q2 what does (Company P) do when customers require a packaging with direct food contact?

The company has only one product at the moment that has direct food contact (bread product). If the customer demanded a direct food contact package they add a special varnish or paper on the inside, which is approved for direct food contact, and cardboards must be Kraft liner type.

In most of the cases, there is a primary package that protects the product. The ink used is only applied from outside and there are additional two layers between the product. Inks used are water-based inks and licensed from ink suppliers. Materials used in direct food contact are virgin Kraft liner. The production manager mentioned that there are no special considerations in the production plant when producing package for food contact.

Based on the author's understanding from interviews with experts, the packaging company uses virgin Kraft liner for all their food products packed as a primary package, and inks and adhesives that are safe for food contact.

4.2 Food companies opinion on cardboard packaging for food contact

(Note: To recall the interviewee's codes please refer to Section 2.3.1: Interview)

Produce safe packaging for food and food contact.

Q1 What steps should the packaging manufacturers do in order to produce safe packaging for direct food contact?

F1 and F2 agreed that in order to produce safe packaging, it is important to identify the type of food to be packed. Some characteristics of food can be described in terms of its fat and water content, temperature in which the product will be packed in, and the production process the food will undergo. F3 stated that it is also important to be aware of how the product will be handled through the whole supply chain, what are

the storage conditions (if the product will be stored in room temperature or if it is a frozen product), the retail conditions or for how long the product will be stored, and the product's shelf life.

To sum up, food companies should be fully aware of the kind of food product the package will be used with (dry, chilled, frozen food), then identify the kind of risks that may cause contamination.

Q2 Do you think that the legislation will be stricter in the future with cardboard packaging materials and the levels of migration?

All interviewed food companies think that legislations for cardboards will be stricter in the future. F1 mentioned that “plastic, as an example, has very strict laws than cardboards; for example, plastic directive has 800 polymers that are set for direct food contact in a certain combination.” F2 stated that “the thinking of how to manage the risks will be applied through the business in all categories.” While F3 pointed out that “it is good if legislations get stricter so food and packaging companies can be more careful during production.”

F1 also added that there can be more demands in declarations of materials information. The development never stands still; consumer demands also change over time. This means that continuous follow-ups are necessary to ensure best performance in relation to product.

To conclude: as knowledge and developments increase through research, what is safe today cannot be considered safe in the future so legislations will be stricter for developing packaging material. In such cases the material suppliers will manufacture new packaging with the new specifications that will be compliant to the updated legislations.

Corrugated packaging for frozen products and legislations

F1 mentioned that “in the case of frozen the products, corrugated packaging is used as secondary packaging. Corrugated packaging is used as a complementary protection for the moist and cold environment. PE or other types of plastic with a wax is used as primary packaging, in which case primary packaging manufacturer follows PE plastic packaging legislations.

As mentioned in literature review there is no harmonized legislation for cardboard packaging in the EU. Due to the lack of scientific proof the EU commission does not want to regulate recycled paper material (Biedermann et al., 2011).

Q3 Have you heard about any food scandals involving corrugated boards?

F1 and F2 stated that there has been a debate about levels of migration of mineral oils, but in the food industry it's about how to maintain quality and manage risks. If a packaging company used recycled material instead of virgin, the potential risks will increase (mineral oil, heavy metals, etc.), then there will be a greater need to control those risks to ensure quality.

The author's reflection: In some cases there is a need for higher quality of material to minimize the risk, and debates show that packaging and food companies have to be more vigilant and not only be cost-driven. This especially the case when there are sensitive food products. In the case of less sensitive products, the used material can be changed depending on the specific use of the package.

Q4 In the case of detection of defects in the final product, who is responsible for checking the products; who decides for a recall?

All interviewed experts stated that food companies are responsible for their final products and demand their suppliers with standards of quality. Food companies should have control one step back in the chain. Suppliers also should have control one step back in their chain (paper mill), and similarly, the paper mill must be responsible one step back in their chain, where the paper fibers come from. Every actor takes responsibility 'one step back' in order to have control through the whole chain. Moreover, food companies rely on technical specifications, certificates and quality control of their suppliers.

F1 stated that "all used packaging material is traceable down to production then suppliers also have their own track and trace system from the raw material, then it may be possible to find the source of defect. In some cases, things can go wrong in more than one place at the same time."

Based on the author's understanding of expert interviews, food companies usually suffer the consequences because of a defective or sub-standard final product. In order to solve such cases, identification of the root cause of the problem and related activities around it should be investigated and addressed.

Q5 Can any machinery used in producing non-food packages be also used to produce packages for direct food contact?

F1 and F3 think that the machinery used to produce packaging for direct food contact can be used for producing non-food contact packages. F2, on the other hand, thinks it

would be better if a separate machine can be dedicated for products which will produce packages intended for direct food contact in order to eliminate the risk of cross contamination. F1 added that “it is all about risk management and having a good planning sequence.” F3 added an example wherein risk management for food packaging companies can be based upon: in some cases, food manufacturers place sensitive product first in the queue for production. Prior to production, the machine used is in its cleanest state due to the cleaning operation performed a work shift earlier. The planning sequence is designed such that the sensitive products are produced first then the less sensitive products follow. At the end of the production run, the machine is cleaned again. The same principle can be applied for packaging companies to ensure safety.

To conclude, it is important to define the risks then find the solutions to manage those risks. Many packaging companies, for example, have two gluing systems, two ink systems - one of which is intended for direct contact and the other for non-direct food contact packages.

Migration from package to product

Q6 How can migration NOT occur from packaging to the food product and vice versa?

Food companies ask their suppliers about migration tests and levels for different hazardous substances like heavy metals, and get certificates from suppliers that the packaging material can be used for direct food contact.

The interviewed food companies pointed out that it is important to have in place GMP and GHP (Good Manufacturing/Hygiene Practices). In the case of paper, material handling should be considered. It is also important to control ventilation, people and the environment in general.

Q7 What are the agents capable of migrating to the food product? What factors affect the rate of migration?

Printing inks: F2 and F3 stated that there are hundreds of different inks from suppliers. Each supplier grades their inks according to their standards. F1 added that many food companies use water based inks.

All interviewed companies believe there can be no risk from inks as it is usually applied outside the box. Water based inks are safe to use.

However, from the author’s point-of-view, inks can still migrate to the food product even if they are only applied on the outer part of the package. A research, mentioned

in the theoretical frame of reference, showed that there can be contact between products and the ink.

Adhesives: Some food companies do not require food safety certificates in all levels of packaging that has no contact with food. However, adhesive for primary packaging should be safe for direct contact with food. Secondary packaging can use an adhesive that is not recommended for direct contact with food. But to be on a safer side, some food companies require their adhesives for primary and secondary packaging to be both safe for food contact.

F1 and F2 assured that their food companies have done migration tests with their products with different packaging material through the new product development process, especially when the product is packed hot or when the final consumer needs to heat the product inside the package

Time and temperature

Temperature is also critical parameter for selection of material with direct food contact (Arvanitoyannis et al., 2004). F2 and F3 stated that cardboard packaging for pizza packs should be handled with more care since the food product is placed in the package while it is still hot. Producers should consider the time and temperature. If contact will be for 2 minutes, for example, it is not the same as 30 minutes in terms of migration and type safety limits.

F3 mentioned “in case of pizza packed by small pizza restaurants, it can be that they do not have enough knowledge about migration and risks. So in principle, if they are not knowledgeable about the risks, they will not take action to avoid it.” F3 continued saying “another problem can be that many consumers cannot see the difference between a box for a pair of shoes and a box which is made for a food product.”

To sum up, time and temperature affect migration (Albu & Buculei, 2011). It should be known in which condition the package will be used in order for food companies to make the right choice for the intended product.

1.3 Paper based packaging for food contact (Opinion of academic experts)

Q1 What is your opinion about the safety of cardboard (solid and corrugated boxes) for primary and secondary packaging?

R1 replied that cardboard can be safely used for both primary and secondary packaging for food. The paper mills in Sweden have a good control of the material produced. R2 also added that in most cases the general public trust that authorities over the fulfillment of regulatory requirements.

Q2 Virgin or recycled material: which one should be used for packaging for direct food contact? Is there a need for functional barriers?

R2 and R3 mentioned that virgin materials are most often used as a primary packaging in the case of direct contact with food. Recycled paper is also possible to use if the paper is coated or an inner packaging is used as in the case of corn flakes.

R1 pointed out that when using only virgin paper material as secondary packaging it is a must to meet certain requirements in the case of products that need protection from damages such as fruit and vegetables in moist conditions.

R2 also added that increasing recycling of paper decreases the fiber quality which means that the number of times a fiber is used influences the performance and cleaning demands in paper making. R1 stated that a general rule is that you mostly use primary fibers for food packaging in direct contact with food and the secondary packaging generally holds recycled paper to a certain extent.

R1 thinks that the decision to choose primary or secondary material depends on the packaging and food company policy and the performance requirements set.

R1 and R3 agreed that a general rule can be that mostly primary fibers can be used for food packaging in direct contact with food and the secondary packaging generally holds recycled paper to a certain extent.

R1 continued saying that functional barriers may be used for primary packaging to influence shelf life of the product. R2 pointed out that functional barrier can be used also to prevent grease to penetrate the material. So each product will set its own requirements.

Q3 Who is responsible regarding the safety of food product through the supply chain?

R1, R2 and R3 responded that the food company is responsible as they have accepted from the beginning to deliver packages that are used in the packing operation. If the food company has packaging demands, they have to ensure that their suppliers provides with the material bought and demanded. As a food packaging companies are responsible for delivery the product to consumer so they are fully responsible for the whole chain.

Q4 What are the main tests that cardboard manufacturers conduct in order to produce safe packaging?

From a food safety perspective R2 replied that it is all about permeability tests that depend mainly on the type of packed product and how the product behaves inside the package.

R1 mentioned that there are performance tests to ensure the protection of the products until its delivery point. For secondary packaging, BCT (Boc Compression Test) or ECT (Edge Crush Test) of corrugated board is performed. SCT (Short Compression Test) and CMT (Concora Medium Test) for the liner material are done to ensure that the box holds to certain limits.

Q5 Is it safe to use recycled packaging as primary packaging?

R2 and R3 were not sure about their answer while R1 stated that it is safe in most cases as it is the case in many pizza boxes (where the pizza is packed for a short time). But to be on the safe side, primary fibers should be used. R1 mentioned that product and the time in which the product will be kept inside the package are key factors. R2 also agreed with this.

Based on understanding of interviews, recycled materials deteriorate as time goes by. Recycling twice poses no problem, but in case of six or seven times, restrictions should be considered.

Q6 Should food companies stop using recycled materials for their packaging?

R1 and R2 agreed that this cannot be the best solution. It is so important that the recycled fibers should be used for the correct purpose.

To conclude recycled material should be used as it is a sustainable resource if handled correctly. It is good to use paper to package food and distribute it to consumers as the product quality may be maintained.

Q7 Were there any scandals relating to food packaging over the last years? And how did the companies overcome it?

Respondents did not mention any scandals but R1 mentioned that in some cases some claims that package performance were below standards. Due to confidentiality issues the answer were not given in a detailed manner.

1.4 Tools to assist packaging company to develop safe for food contact cardboard packaging

The packaging company has a central software system (XS) where in every project is added. The information on this system is shared between the different departments involved in the packaging development process.

As this system has been developed years ago, there has not been any part developed in the system for food packaging requirements regarding food safety. The author has developed a template that can be added to the system as a tab specifically for food packaging requirements with inputs for different products. It also included formulated questions to check on the food safety requirements. This tab on the wizard can be called 'Critical to food product and food safety' where all the necessary information about the packaged product, temperature, contact with packaging etc. can be added. If the customer did not suggest a material to be used, a study can be done to determine the requirements of the food product—the results of those questions in the template can help to identify which type of material and processes can be used and which tests should be checked.

4.4.1 System template for XS

Table 9 shows the further development to the main tab system, Food safety, XS (Critical to food product and food safety')

Properties of packaged food	
1) Physical state of packed product: Choose an item. 2) Packaged food characteristics:- Choose an item. Others Click here to enter text. 3) Chemical Characteristics: Choose an item.	Water content% Click here to enter text. Fat content% Click here to enter text.
Food contacts with packaging and barriers	
Direct Food contact <input type="checkbox"/> Yes <input type="checkbox"/> No Barriers: Choose an item. Description: Click here to enter text.	Days of direct contact no.
Temperature of packaged product	Usage of package by customer
Product: Click here to enter text. Status packed: Choose an item. Max & Min temp. (°C) Filling temp.(°C)	Food heated with package: <input type="checkbox"/> Yes <input type="checkbox"/> No Temp (°C) Time (min)
Critical to food safety	Food Manufacture requisite
Migration test <input type="checkbox"/> Heavy metals test (printing inks) <input type="checkbox"/> Others Click here to enter text.	Type of ink used Click here to enter text. Amount of ink applied: Click here to enter text. Suggested Adhesives Click here to enter text.
Specification & Legislations	
Food company specification <input type="checkbox"/> Yes <input type="checkbox"/> No Packaging specification: Click here to enter text.	
Other information' Click here to enter text.	

Customer:-Click here to enter text.

Article:-Click here to enter text. Date:-Click

here to enter a date.

4.4.2 Logic Diagram

A preliminary logic diagram was developed which can be used as a complementary part to the template illustrated above. The diagram can be used to help the sales and design departments in proper material selection, by identifying the risk levels after consideration of the different characteristics and properties of products.

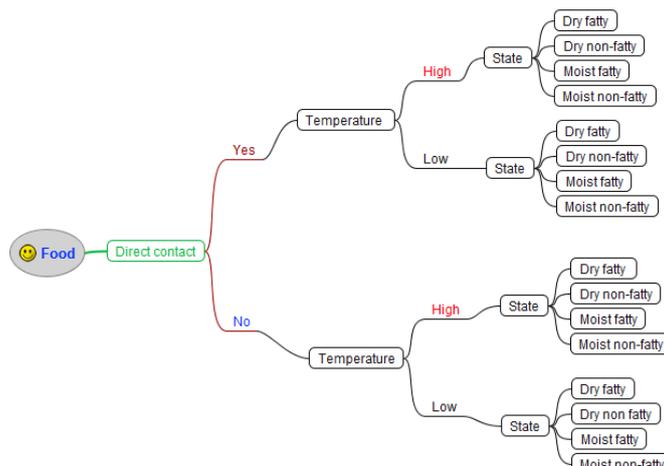


Figure 8: Logic diagram

The products were divided in two categories: high in risk indicates that special consideration is needed in the design and manufacturing processes, unlike the category, which are products that are low-risk. For example, Product A is pizza, which is high in fat and moisture content, packed in high temperature. The risk of migration of hazardous substance is also high. Microbiological activity can also be high, which indicates that time and temperature are important factors. Consequently, organoleptic properties (taste and odor) can be affected, as mentioned in a study by Tateo et al. (2009).

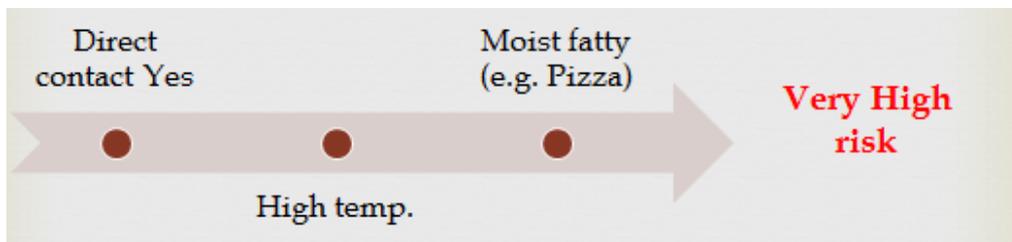


Figure 9: Product ‘A’ with high risk

The second example is a low risk product, bread. It is packed in lower temperature, On the other hand, if it is a dry and non-fatty product, it indicates that microbiological activities are low and the migration will be lower than the previous example.

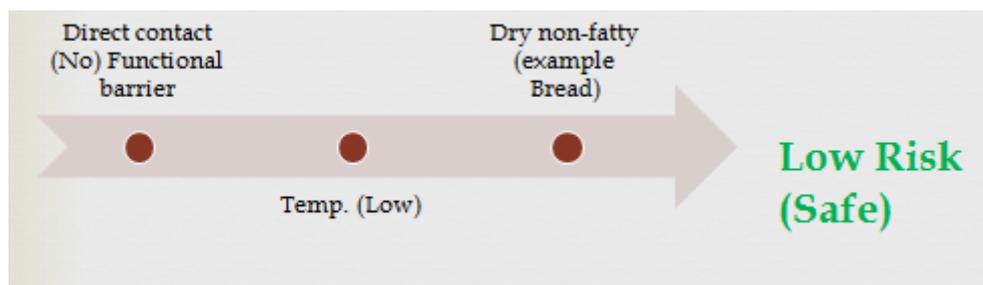


Figure 10: Product ‘B’ with lower risk

4.4.3 Questions developed for sales representative to be addressed to food companies:

It would be beneficial for the sales department to use a checklist to ask specific questions to their customers (food producers). After analysis of the interview transcripts, related literature and observations, the author was able to formulate important questions which can be asked to the food manufacturers in order to identify the main needs of the packaged food in terms of packaging requirements, to be able to ensure the safety of the packaged products throughout the supply chain. By asking the right questions the sales representative might be able to suggest the safest material that can be used to protect the product. There may still be a need for risk analysis that should be performed in case of any doubt.

The questions were classified in to 3 main parts:

Product: The food company needs to answer questions about the nature of the product;

Product requirements: Includes questions about temperature and shelf life; main requirements the package needs to have;

Customer Requirements: In case the company has any suggestions for the best package that suits them to protect their product from a food safety point of view.

Table 10 Sales template questions

<ul style="list-style-type: none"> • Questions developed for sales representative to ask to food companies: 	
<p>I. Product:</p>	<ul style="list-style-type: none"> ✓ Agro alimentary product (fruit or vegetable)? Is it edible with the peel (e.g., tomatoes) or it should be peeled before (e.g. potatoes, oranges) ✓ Processed product (e.g., meat, pizza, hamburgers)? ✓ The water content of the product? Is it a dry product or high in water content? Humidity inside the package, how much? ✓ Percentage of fats? High fat? Low fat content? ✓ Is it solid or liquid?
<p>II. Product requirements:</p>	<ul style="list-style-type: none"> ✓ What is the temperature of the packaged product? What temperature should the product be kept at? Mention the highest and lowest temperature of the product inside the package. ✓ Frozen product? Or kept at room temperature? ✓ Estimated shelf life of product? Long or short shelf life? For how long the package is in contact with the packaging? ✓ Is there primary packaging or direct food contact? Is there a barrier between the packaging and the box? Primary package? Functional barrier?
<p>III. Customer requirements:</p>	<ul style="list-style-type: none"> ✓ Requirements for a special material to be used? ✓ Type of ink and adhesive applied? ✓ The amount of ink applied in printing? ✓ Are there any internal printings? Type of ink used? Migration? ✓ Are there any migration tests that need to be checked? ✓ Has the food producer company done any tests for migration? Amount of MOSH (mineral oil saturated hydrocarbons) before packing the product? ✓ Heavy metal test (for printing inks)

These developed tools and checklist have been presented to the packaging company, (Company P). Different departments involved in the packaging development process have shown support and have agreed on the content that it would indeed be beneficial for the company to use such tools in their packaging development process.

5 Discussion

This chapter aims to discuss the findings in the theoretical chapter as it relates to results from the interviews.

5.1 Discussion on formulated themes

As mentioned in the methodology chapter, the results of this research are presented and discussed through four main themes. The first three themes are discussed in this part (5.1), while the fourth theme is given a separate section (5.2), due to its broader nature, and thus longer discussion.

5.1.1 Considerations for using recycled materials for food contact products

The use of recycled material for direct contact with food is permitted in some European countries. “7 out of 10” of the interviewees agreed that packaging companies should continue to produce packages from recycled material, but the material needs to be controlled properly with knowing the source of the raw materials through an efficient track and trace system.

F2 company uses virgin fibers in their primary packages while F3 company use recycled material for some of their products as a primary packaging. As discussed in the frame of references, Swiss, German, and Romanian researchers have detected mineral oils compounds (mineral oil saturated hydrocarbons or MOSH) in food products packaged in recycled material, which may have an effect on human health. Mineral oil migration can occur from recycled boards and paper especially from the printing inks used in newspaper and magazines. Thus, based on those studies, the author’s suggestion is to use virgin materials for primary packaging. If the company decides to use recycled material, it is only permissible if there is a barrier inhibiting migration of contaminants.

Another problem can be the migrations limits; until this moment there are no migration limits for mineral oil in foods regulated by the European Union, (Misko, 2013). All interviewed food companies mentioned that they perform migration tests with their packaging suppliers. As discussed with companies, migration test are very expensive and they are not done more than twice a year. The author believes that there is a need for more frequent testing (e.g. once every two months), although this

will evidently have economic implications for the company and also, for the end consumers. It is important to have more stringent measures so they can ensure to their customers that they have packages that do not have contaminants beyond set limits. The issue here is how these two needs can be balanced – product safety and economic viability.

At Company P all the packages produced for direct food contact are produced from virgin fibers in order to avoid all the potential risks that can occur. Ninety percent of interviewees mentioned that the safety of food packaged in cardboard packages depend on many factors, and not only on material, e.g., the sensitivity of the product, the physical, chemical and microbiological properties of the food and the time and temperature of the food inside the package.

5.1.2 Harmonized legislations and further research

The EU does not have harmonized legislation for the use of food-contact paper and board materials (Albu & Buculei, 2011). More research is needed by the food authorities and researchers to help packaging and food companies produce safer packages for foods in the future. Interviewees from food companies mentioned that if the legislation gets stricter, that would result to more careful operations. There is a need to have harmonized legislations for the cardboard industry, organized by the EU. The author expects that in the next couple of years there would be more research in the area of cardboards and materials in direct food contact.

5.1.3 Unique selling point

In June 2012, the European Food Safety Authority (EFSA) mentioned that there is potential for presence of mineral oil hydrocarbons in foods from packaging. This can have health effect on food consumers. Using virgin boards has a high cost; also, cutting trees to produce such virgin boards is not considered environmentally friendly. There is an opportunity to have a unique selling point for packaging companies by developing packages that contain functional barriers to avoid hazardous substances.

Food companies, as well as the final consumers, may be willing to pay more if packages were proven to be safer than its competitors, and this can open new markets to packaging companies and increase their sales. The author believes that if an efficient functional barrier is used (e.g., PET), then another issue comes in mind, which is about separation of those materials when it comes to the recycling stage.

It should also be considered that only using different materials will not prevent all the possible risk of contaminations because contamination can occur from other sources in the supply chain, e.g. through transportation or machinery, which can have dangerous levels of mineral oils or heavy metals that may transfer to packages then afterwards to foods (Grob, 2011). Ultimately, the best solution is to have a complete, holistic system that assesses all the possible risks, and not just risks related to the material.

5.2 Areas for improvement in a packaging company (Company P)

A core issue in new product development is effective and efficient communication (Tushman & Katz 1980). The author has observed and monitored the system (software) for internal communication within the packaging company (XS), where different departments share all the needed information for each packaging development project. Through observing different departments involved in packaging development process, and after conducting interviews with different personnel, the author was able to understand the company's packaging development process and found that the process at the early stage identifies that the developed packaging will have direct food contact. However, there are still areas for improvement.

To produce safe packaging, the new product development process starts with specification planning. It is important during the early stages of development to know the type of food product, the processes that the packaged product will undergo, and how the product will be handled through the supply chain (Stehlin, 2011). Once this information is provided, communication between different actors within the packaging manufacturer is established to respond to their customer's needs. Each actor in the company responds based on the responsibilities that were assigned to them.

As for the system for internal communication that was developed years ago, the author found that there was a need to develop a checklist template specifically for food safety, where all the collected information regarding the product requirements and food safety will be encoded. This template will help sales personnel to get more understanding of the packaged product and identify the possible hazards depending on the nature of the food. Consequently, other departments involved in the packaging development process can be more cautious in designing, material sourcing and producing the product. No packaging material can fulfill all these roles alone, because any of them is characterized by both advantages and disadvantages. The

trend is to combine different packaging materials with the aim of eliminating the disadvantages while using the advantages (Albu, 2006).

Responsibilities of each department in new packaging development process for food:

What was lacking in the process in order to ensure that direct food contact requirements are sufficiently considered in development projects where food safety requirements apply?

When producing a package for a food product, special consideration is needed because foodstuffs have special requirements. The main roles of packaging for food are protection of food products from outside influences or damage, protection from contamination, traceability and information (Marsh & Bugusu, 2007).

In order to produce safer package for direct food contact there is a need for improvements in the internal and external communication within packaging companies. Additional responsibilities also were recommended to different departments in the packaging firm. These recommendations were based on analysis of interview results and related literature.

Starting with external communication with food companies:

A) The sales department needs to clarify with their customers (i.e., food companies) the intended use of the package, type of food, storage conditions and other questions regarding food safety, as has been discussed by the author in the results section. The formulated questions can be used to help sales representatives in asking all the necessary questions to help in the production of safe packaging. Most interviewees agreed that by identifying the nature and requirements of each food product from an early stage in the product development process, this would lead to the development of a better and safer package. The author developed questions and a logic map to help sales representatives to ask the appropriate questions to their customers.

After that comes the internal communication within the company:

B) Design department: The design department is currently responsible for the graphical and structural design of the product.

As mentioned in the PAS: 223 in point 19.3:

1) Documentation is needed to prove the suitability of materials for the intended use. For each product there are specific needs depending on the nature of the product and its interaction with the package. Migration data for each product shall be demonstrated and documentation for the right printing

process which assure food safety. The amount of ink applied and the proportion to ink to the content's weight and surface must be considered for migration risk assessment

- 2) Adhesives. As mentioned in literature there is a potential for migration from the adhesive to the packed product, tests are needed to be performed on each product and food contact adhesives to be used. As interviews with food companies show that some companies use non-food contact adhesives for secondary packaging, while research showed that migration can still occur. Further tests are needed in this area.

It is recommended that the design department be responsible for selecting the right printing process, and potential migration must be taken into account when producing packages for food. "The amount of ink applied and the proportion of ink to the content's weight and surface must be considered in migration risk assessment" (Stehlin, 2011). Regarding adhesives, there is a potential for migration to the packaged food so it is important to choose the right adhesive for food product as it is important to choose the inks and coatings.

- C) Production department (Printer): From the data collected from sales, and the system template by the work done by designers, it is recommended that production follows a quality assurance system.

Production: for producing safe food package, complete hazard assessment should be defined as well as food safety hazards. Biedermann et al., (2011) stated that "Using Kraft liners instead of recycled material is not enough to stop migration and eliminate contaminants." As mentioned in the theoretical chapter Stehlin (2011) states that migration can happen through invisible set-off if the ink touches the surface which will have direct food contact. Therefore, there should be a system that protects the food-contact side from microbiological, chemical and physical contaminants. Applying good hygiene and manufacturing practices to raw materials, products and people can help eliminate contaminants. Migration can also happen through the package headspace. As mentioned from interviewed experts and food companies, the equipment should be cleaned before producing packaging for direct food contact to prevent contamination. Special care should be given to the selected ink to avoid contamination. Cleaning programs and inspections shall be implemented to avoid pest activities. PAS: 223 food safety specifications should be maintained and developed as well as compliance with the migration limits and data.

“4 out of 10” interviewees mentioned that through the production process, the machinery used for producing packages with direct food contact can be used as well for production of non-direct contact by having a clean in place (CIP) system. 20% preferred using a separate machine for production of packages with direct food contact to avoid cross contamination; it was because of their concern about the risks that contaminants can be transferred to the food. The author believes that it is possible to have proper production sequencing; for example, production runs of packages for food contact should be done first before the packages for non-food contact. Then, the whole system will be cleaned to avoid the possible risks from machinery and overall production area.

- D) Purchase: If the first three actors followed those recommendations, the purchasing department will be able to source the right material. It is recommended also that the packaging company should give recommendations to food companies on how the product should be filled and how the package should be treated throughout the whole supply chain.

For a section summary, to better see the differences between the company’s current situation and the author’s recommendations on the different departments’ responsibilities in the packaging development process, please refer to Table 11 below.

Table 11: Summary of the company's current situation and the author's recommendation on department responsibilities

	Current situation	Recommendation to produce for direct food packs
Sales department	<ul style="list-style-type: none"> • Collect all needed information and customer requirements 	Ask the appropriate questions on food safety depending on nature of each product
Design department	<ul style="list-style-type: none"> • Packaging concept • Design • Printing process 	<ul style="list-style-type: none"> • Documentation • Migration data • Amount of ink applied to package. • Adhesive and ink selection depends on product requirements to insure safety.
Production department	<ul style="list-style-type: none"> • Packaging production • Production Risk assessment • Quality assurance 	<ul style="list-style-type: none"> • Good hygiene and manufacturing practices including equipment cleaning and people hygiene. • Production sequence (produce package which have direct food contact first then without food contact packages. • Control all microbiological, physical, chemical hazards when producing package with direct food contact. • Machine setup for production of direct food contact. • Applying food safety standards like FSSC 22000,HACCP
Purchase department	<ul style="list-style-type: none"> • Purchase orders the needed raw material from suppliers as the best cost • Checking compliance 	<ul style="list-style-type: none"> • Coordinate with quality control to insure that regulations are compiled well.

6 Conclusion and further research

The focus of this study is to assess the current process of cardboard packaging development at Company P (Sweden) from a food safety perspective. The research aims to identify what is lacking in this process to be able to present recommendations that will help ensure that the requirements for direct food-contact packaging are sufficiently considered in their development projects. Also, the research aims to get a holistic view of food companies' and experts' opinions about using cardboard (corrugated and solid) in the food industry as a primary and secondary packaging.

There are more guidelines needed in the production of packaging intended for direct food contact in order to produce safer packages. Responsibilities were suggested to each department to help produce safer products. Different departments within the company are recommended to have greater awareness of the possible risks, and to act accordingly based on this.

Each food product has specific packaging requirements. To help in identifying and addressing these requirements, a template for sales, a logical diagram and system template for various departments were designed to facilitate and improve internal communication within the company. Additionally, the templates were constructed to help the packaging company in their development process, such as asking the appropriate questions to their customers, identifying the needs of each product, and sourcing the right material to be used for the packaging.

As food and packaging safety, human health, and sustainability are very important issues, food manufacturers and researchers need to work together in order to find alternative packaging solutions and functional barriers that are safer but are also sustainable in the long run. Food and packaging companies alone cannot do packaging development; they should have more collaboration with the academe or other organizations and consortia, to come up with solutions that are not shortsighted. Greater collaboration with the authorities is also needed to have a harmonized legislation for the use of paper and cardboard for direct food contact.

Using virgin material for packages intended for direct food contact can be a short term but safer solution for any packaging company that does not have full control on the migration limits of hazardous substances for recycled raw material. Another possibility that can be considered is by developing more sustainable packages made

from recycled material with functional barriers that may prevent hazardous substances from migrating to food. A packaging company can have a unique selling point if they could produce recycled packages that are more environmentally friendly but lesser in cost.

Lastly, safety of food products can be fulfilled through the collaboration of every stakeholder in the entire supply chain starting from sourcing, production, processing, up to the delivery of the end product. Existing systems such as GMP, GHP and HACCP can be used as an effective tool to fulfill food safety requirements.

Further studies

Further studies can be done to improve the developed tools (logic diagram and template) that have been developed by the author for the packaging company in this research. These tools are meant to identify the risk level based on the nature and requirements of different food products that will have either direct or non-direct contact with the package. Further refining and improving these tools would definitely be beneficial for both the food and packaging companies because they will be able to better choose the processes throughout the value chain and the optimal packaging material for a product.

In addition, there is still a lot of research to be done on different types of materials to be able to find and develop better functional barriers that can completely prevent the migration of hazardous substance from the packaging to the food product.

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Appendix

Interview Guidelines:

Each interview will start with an introduction, an explanation of the purpose of the study and some relaxing icebreaker questions (e.g., what is your name? What is your current position? For how long have you been working with the company? What is your background?) Then, the technical questions follow.

Interview questions:

A) Interview questions to professors and experts in the field:	
1	What do you think about the safety of cardboard (solid and corrugated boxes) as a food packaging for primary and secondary packaging?
2	Who is responsible, food or packaging companies regarding the safety of food product throughout the supply chain?
3	What are the main tests that cardboard manufacturers should check in order to produce safe packaging?
4	Virgin or recycled material (which one should be used for direct food production)? What about functional barriers?
5	Do you think it is safe to use recycled cardboards for food without a direct contact?
6	Should food companies stop using recycled materials for their food products? Sustainability issues?
7	Can you tell me about any scandals from packaging to food over the last years? And how did the companies overcome it?
8	What about traceability through the supply chain?
9	Do you think that the legislation will be stricter in the future with packaging manufacturers?
10	Thank you for all the valuable information, is there anything else you'd like to add before we end?
B) Interview questions with food companies:	
1	What do you think about the safety of using cardboard (solid and corrugated boxes) as a food package (primary and secondary packaging)?

2	Is it safe to use recycled cardboard packaging for food with or without direct food contact?
3	Which tests should be checked to assure the safety of packaging? (E.g., migration test, heavy metal tests, mineral oils, etc.)
4	Have you heard about any food scandals from corrugated or solid board regarding food packaging over the last few years? Can you please state any?
5	What about traceability through the supply chain? Who is responsible food or packaging manufacturers about the safety of the packed product?
6	How packaging manufacturers should do in order to produce safe packaging for direct food contact?
7	How food manufacturers should handle packaging in order to assure food safety?
8	Can machinery used in producing non-food packages be used to produce packages of direct food contact?
9	How migration can occur from packaging to the food product and vice versa?
10	Should Inks be used in corrugated boxes for food production? Water based inks are safe? Adhesives?
11	Do time of packed product and temperature affect the migration levels?
12	Do you think that all packaging manufacturer check/follow those migration limits?
13	Do you think that the legislation will be stricter in the future with packaging manufacturers regarding the levels of migration?
14	Thank you for all the valuable information, is there anything else you'd like to add before we end?

C) Sales Interview: Interviews with different departments within packaging company (Company P)	
1	In which way exactly sales are involved into new packaging development?
2	What kind of questions do you ask to your customers?
3	What do you do with the collected information?
4	Which departments have direct contact with customers (e.g. sales, design, purchase and production)?
5	What do you ask customers in early stages to identify whether the packaging to develop is supposed for direct food contact?

6	Which questions do you ask to customers when direct food contact is the case?
7	And how much of the information collected from customers is shared with other departments?
8	Which method you use to communicate with other departments? e.g.(emails, documentations or software's)
9	What is the expected sequence of information flow between sales and other department in the process of new packaging development?
10	If a template was designed as a supportive tool to help designers and sales managers before or during the project which questions would you like to include?
11	What do you believe is important to include in the tool?
12	Would you include additional questions if direct food contact is the case?
13	Thank you for all the valuable information, is there anything else you'd like to add before we end?

D) Purchase Interview: Interviews with different departments within packaging company (Company P)	
1	In which way exactly purchasing is involved into new packaging development?
2	From which department do you get information?
3	What information do you receive from other departments to select a material for new packaging developments?
4	Do you have special routines for products with direct food contact?
5	Which department informs you about whether the packaging to develop is supposed for direct food contact or not?
6	What are the materials used in the case of packaging with direct food contact?
7	What are the tests needed to be checked to assure that the material is safe for direct food contact?
8	What are the steps taken: especially when you know that the package will have direct contact with food?
9	Is there different inks used when direct food contact is the case
10	What are those different requirements?
11	Thank you for all the valuable information, is there anything else you'd like to add before we end?

E) Design Interview: Interviews with different departments within packaging company (Company P)	
1	How design is involved in to development of new packaging?
2	Which information do design people receive to develop new packaging?
3	Is there other information do you receive from other departments (e.g. sales, purchase and production?)
4	Which information do they pass on to other departments?
5	What are the differences in needs between designing packaging which will have direct food contact with packaging which has not? (e.g. ink used or package thickness)
6	What type of information you expect to receive when designing a packaging which will have a direct food contact?
7	From which department you expect this data? And When?
8	Thank you for all the valuable information, is there anything else you'd like to add before we end?

F) Production Interview: Interviews with different departments within packaging company (Company P)	
1	How production is involved into development of new packaging?
2	What information do you receive from e.g. design or purchasing department regarding production of new packaging?
3	Why do you need to know if a package to produce will have direct food contact or not?
4	Are there any difference between the production of packaging for direct food contact and other packaging?
5	How long in advance do you need to know if a package to produce will have direct food contact?
6	How do you consider direct food contact requirements during production planning and set-up?
7	Thank you for all the valuable information, is there anything else you'd like to add before we end?