LATE STAGE CUSTOMIZATION IN THE CHEESE PACKAGING PROCESS

A study on the packaging customization possibilities in a cheese packaging factory.

Bachelor's Final Assignment

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Dutch Summary

Deze opdracht is gericht op de mogelijkheden voor een uitgestelde individualisatie voor kaasverpakkingen. Het bestaat uit een onderzoek van het huidige verpakkingsproces en een onderzoek over mogelijke technieken.

De opdrachtgever is het bedrijf Koninklijke FrieslandCampina, die zijn R & D-faciliteit in Wageningen heeft. Het bedrijf produceert en verkoopt consumentenproducten op basis van zuivel die over de hele wereld verkocht worden. Bovendien worden producten geleverd aan bedrijven en verkoopt FrieslandCamina ingrediënten en halffabricaten aan fabrikanten. Dit leid tot een jaarlijkse omzet van 11,3 miljard euro en maakt FrieslandCampina een van de grootste zuivelondernemingen in de wereld.

De huidige kaas verpakking bestaat uit verschillende soorten kaas en verschillende soorten merken. Dit resulteert in veel verschillende bedrukte verpakkingen, wat het een kostbaar en complex proces gemaakt. De supply chain management van deze fabrieken heeft gevraagd om een minder complex verpakkingssysteem, die gemakkelijker kan worden gecontroleerd en efficiënter werkt.

FrieslandCampina bedacht dat verschillende bedrukte verpakkingen via een uniformere verpakkingslijn kunnen worden gemaakt, met een individualisatie stap aan het einde van het proces. FrieslandCampina is ervan overtuigd dat uitgestelde individualisatie de logistieke efficiëntie kan verhogen en kan leiden tot kostenreductie.

Dit idee werd omgezet in de volgende onderzoeksvraag:

> "Welke individualisatie stappen kunnen in de kaasverpakkingslijnen van Wolvega worden geïmplementeerd om lijn efficiëntie te verhogen, te voorkomen dat verpakkingsmateriaal wordt weggegooid en de flexibiliteit van de productie verhoogt?”

Om deze vraag te onderzoeken, werd een onderzoek gestart om de huidige werkwijze en de vereisten te onderzoeken. Deze eisen werden gebruikt als leidraad voor een vooronderzoek over individualisatie mogelijkheden voor de Wolvega kaasverpakkingslocatie van FrieslandCampina.

De resultaten van dit onderzoek kunnen worden gebruikt om te bepalen of een multidisciplinair team moet worden gestart voor verder onderzoek in mogelijkheden voor uitgestelde individualisatie.

English Summary

This assignment is aimed at the possibilities for late stage customization for cheese packaging. It consists of a research of the current packaging process and a study on possible techniques.

The employer is the company Royal FrieslandCampina, which has its R&D facility located in Wageningen. The company produces and sells dairy based consumer products all across the world. In addition, products are supplied to professional customers and sells ingredients and half-finished products to manufacturers. This creates an annual revenue of 11,3 billion euros and makes FrieslandCampina one of the largest dairy companies in the world.

The current cheese packaging process consists of various types of cheeses and brands. This resulted in a lot of different printed packages, which made it a costly and complex process. The supply chain management of these factories asked for a less complex packaging system, which can be monitored more easily and be more efficient.

FrieslandCampina figured that different printed packages can be put through a more uniform packaging line, with a customisation step at the end of the process. FrieslandCampina is convinced that late stage customization can increase supply chain efficiency and can result in cost reduction.

This idea was converted to the following research question:

> *"Which late stage customization steps can be implemented in the cheese packaging lines of Wolvega to increase line efficiency, prevent obsolete packaging material and increase production flexibility?"*

To investigate this question, a research was started on the current process and its requirements. These requirements were used as a guideline for a preliminary research on customization possibilities for the Wolvega cheese packaging location of FrieslandCampina.

The results of this research can be used to determine if a multidisciplinary team has to be started for further research on late stage customization possibilities.

Preface

An introduction to my bachelors assignment

For this project, I have been given the great opportunity of working alongside the Global Packaging Development team of the Royal FrieslandCampina in Wageningen for four months. My gratitude goes out to everyone at FrieslandCampina who made me feel at home and part of the team during my stay there. They gave me a great view on how a massive company can have an international team that works together like a family.

I would like to offer my heartfelt thanks to the following people, for investing their time in me and helping me along the way.

Firstly, **Carla Cornelissen**, FrieslandCampina's Senior Packaging Developer, for coaching me during the project. Her experience and kind tips helped me during my research and especially during fairs we attended together. It was very nice that she always made time for short questions during the day in between her projects.

Bjorn de Koeijer, for helping me with goals, possibilities, giving sound advice and guidance. His own experience helped me a great deal.

The whole **Global Packaging Development team**, for the refreshing talks during the lunch breaks. The casual atmosphere was very nice to have and was something which I didn't expect to have with such a large company.

All in all, this was an amazing learning opportunity for me. I hope that during this project I have shown my potential. Working together with packaging professionals without a packaging background was challenging, but a great learning experience.

Glossary

Primary packaging	Plastic packaging containing cheese
Secondary packaging	Carton boxes containing primary packaging including box labels
Tertiary packaging	Transportation pallets, wrapping foil and pallet labels
Drop on demand(DoD)	Inkjet printing technique that uses nozzles to place ink droplets
Wide web printing	The printing process which prints on wide substrates
Narrow web printing	The printing process which prints on narrow substrates
QR code	A matric barcode which enables a link to an internet website
SKU	Stock keeping unit
OEE	Overall Equipment Effectiveness: how effective the process is
UV	Ultraviolet Light

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1-Introduction

1.1 Employer: the Royal FrieslandCampina

Royal FrieslandCampina provides millions of consumers from all over the world with dairy products, containing valuable nutrients. They supply products such as dairy based beverages, nutrition for children, cheese and desserts in many European countries, Asia and Africa. Besides consumer products, Friesland Campina also focusses on professional customers including bakeries and food-services companies as well as manufacturers of nutrition for children, the food industry and the pharmaceutical sector. With annual revenue of 11.3 billion euro, FrieslandCampina is one of the world's largest dairy companies (FrieslandCampina, 2016 A). The different brands of FrieslandCampina are shown in image 1,2 and 3 (FrieslandCampina, 2016 B).

Image 1: Ingredient brands.

Image 2: Consumer brands.

Image 3: Professional brands.

The history of FrieslandCampina goes back to the 1870's. In 1871 Dutch dairy farmers joined forces in local cooperative dairy factories. One of the reasons for doing so was the lack of refrigeration. The farmers had to work together to deliver the milk quickly to their customers. Another reason to join forces was to gain more power in the market.

Later local dairy factories merged into regional dairy companies, such as DOMO or Coberco. This merging kept on going through the years including a merger with the German company Milchwerke. The final merger was in 2008. FrieslandCampina comprised out of two great Dutch dairy companies: Friesland Foods and Campina (FrieslandCampina, 2016 C). But also after 2008 many reorganization happened within the company. New locations were opened, old ones are closed or reorganized. Due to this long history of mergers, many different ways of working exist within the company. It has therefore been a challenge to centralize knowledge and information within the company.

1.2 Company Structure

FrieslandCampina has offices in 32 countries and employs over 22,000 people. FrieslandCampina's products find their way to more than 100 countries. The Company's central office is based in Amersfoort. FrieslandCampina's activities are divided into five market-oriented business groups:

- Consumer Products Europe, Middle East & Africa
- Consumer Products Asia
- Consumer Products China
- Cheese, Butter & Milkpowder
- Ingredients

The cooperative Zuivelcoöperatie FrieslandCampina U.A. is owned by the member dairy farmers. These farmers choose representatives of the 21 districts (10 per district). These representatives from the District Council, which links the cooperative Zuivelcoöperatie FrieslandCampina U.A. and the company FrieslandCampina N.V. The Members Council approves the decisions made by the Board of the Cooperative insofar as necessary.
At the end of 2014 FrieslandCampina had 19,054 member dairy farmers who owned 13,969 dairy farms. Together they supplied 9,453 million kilos of milk.

Image 4 shows the hierarchical structure of the company.

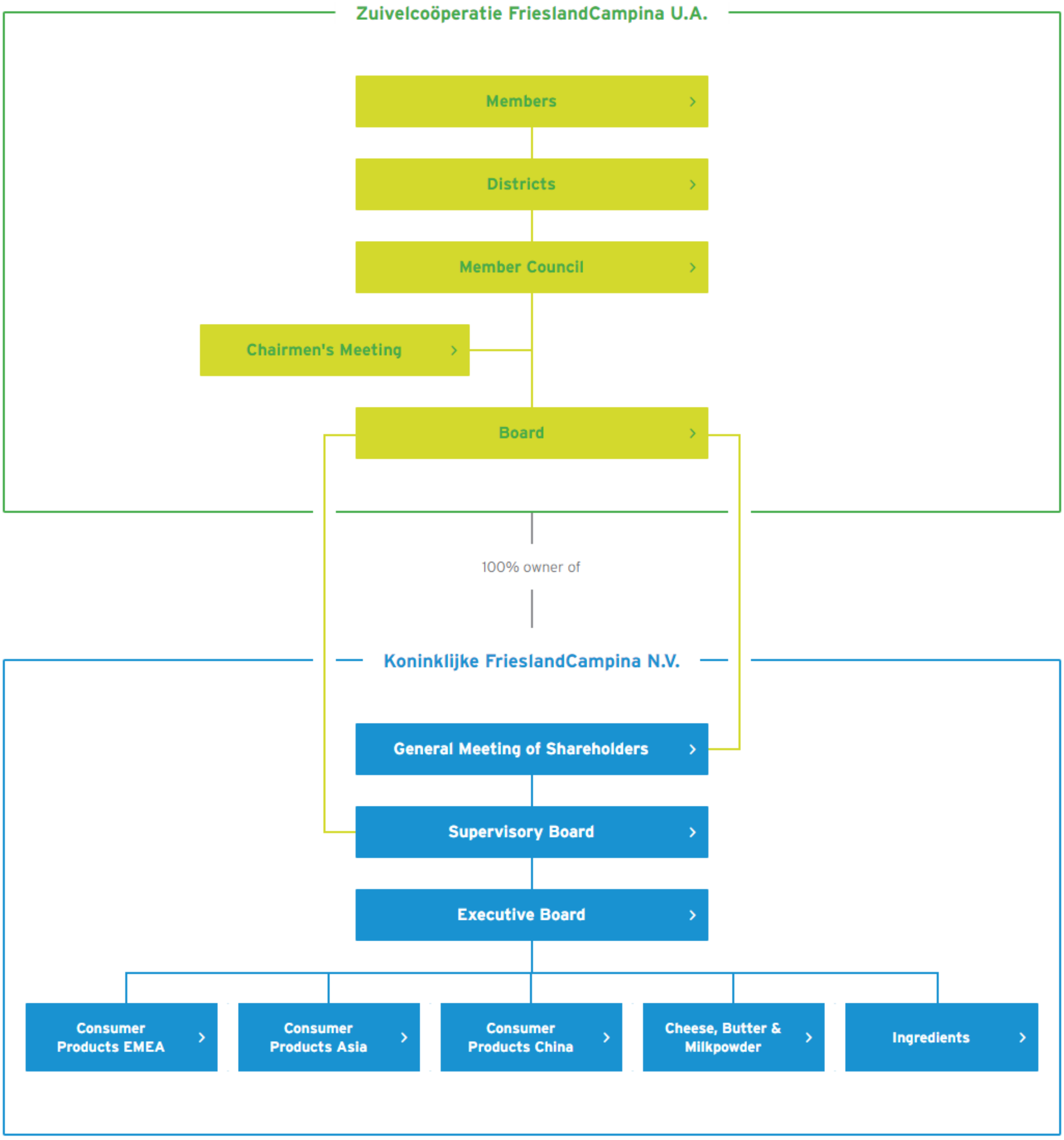

Image 4: Hierarchical structure.

Consumer Products Europe, Middle East & Africa (EMEA) is one of FrieslandCampina's four business groups. Each business unit consists of several operating companies. The operating companies from Consumer Products EMEA are active in Europe, the Middle East or Africa. Their 'home base' is in the Netherlands, Germany or Belgium, but they also have production outlets in France, Russia, Greece, Hungary, Romania and Nigeria, as well as sales offices in the United Kingdom, Spain, Italy and the Middle East.
The business group FrieslandCampina Consumer Products Asia consists of operating companies that are active in the consumer products segment in Asia. FrieslandCampina has acquired excellent positions in many countries with strong brands and a wide range of products.

Because of the size of the Chinese market, Consumer Products China has been separated from Consumer products Asia.

Furthermore, the business groups Cheese, Butter & Milkpowder and Ingredients consist of all the products, packaging and procedures related to cheese, butter, milk powder and the companies that produce the ingredients (FrieslandCampina, 2016 D).

The Research & Development department of FrieslandCampina has two locations: The Innovation Centre in Wageningen and the Development Centre in Singapore. The Innovation Centre combines research & development, marketing, sales and supply chain disciplines to improve its innovative power. The Development Centre focusses on the development of dairy based beverages and infant and toddler nutrition, tailored for Asian consumers (FrieslandCampina, 2016 E).

1.3 Wageningen

Since September 2013 the FrieslandCampina Innovation Centre (image 6) has been built to centralize the research & development. Scientists have the possibility to develop new food products, processes and applications using all nutrients and components found in milk. Research is mainly focused on nutrients of milk as well as growth, development, health and well-being of consumers all over the world. By centralizing scientific knowledge FrieslandCampina wants to strengthen its innovative power.

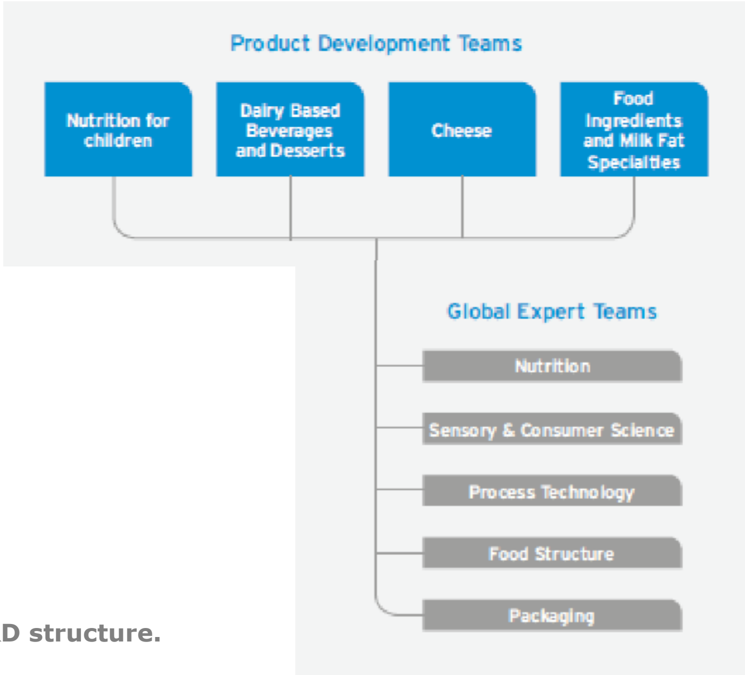

Image 5: R&D structure.

R&D is structured in four different product development teams (image 5): Nutrition for children, Dairy Based Beverages and Desserts, Cheese and Food ingredients and Milk Fat Specialties. Five Global Expert teams support product development, being: Nutrition, Sensory and Consumer Science, Process Technology, Food Structure and Packaging (FrieslandCampina, 2016 F).

Image 6: FrieslandCampina Innovation Centre.

1.4 Global Packaging Development

The Global Expert team responsible for packaging is the *Global Packaging Development* team.

This team consists of 24 employees in the Netherlands, Germany, Belgium and Singapore, including the cluster managers. Together they cover the categories: Consumer Products Europe, Consumer products Asia, Butter and Milk Powder. The category ingredients is not included in the *Packaging* department and executed at the plant in cooperation with packaging engineers. Before the merger in 2008 there has been very little contact between the different clusters. The division was divided by categories rather than the expertise. This way knowledge and experience regarding packaging development could not be exchanged easily. Since the merger, the focus has been on centralizing expertise to improve professionality.

Although graphical packaging and structural packaging make up packaging, the *Packaging* department is not responsible for graphical packaging. The *Print* department, in cooperation with an external design agency and the *Marketing* department develop the artwork. Once decided, the *Print Development* department discusses the artwork with the supplier of the substrate. The right balance between costs and appearance is established. The *Packaging Development* team determines the material and the shape of the pack. This process involves taking the requirements of *Marketing*, creating a feasible idea, converting it to a three-dimensional model, determining the required material with suppliers, adjusting the design to fit purchase costs and creating a design that can be produced in the production line without exceeding tolerances, while maintaining the original idea.

As all these parties are involved, a good cooperation between the *Packaging* department, the *Print Development* department and the *Marketing* department is required. The *Packaging Development* department is responsible for the technical aspects of product labels. These technical aspects include the material, the size and the usability of the labels. These aspects are developed in collaboration with the *Production* department. However, *Marketing* will eventually decide if the quality of the label suits expected appearance, which is why the development teams are multidisciplinary.

The *Global Packaging Development* team consists of four clusters representing the product development categories. The cluster Solids & Powders is responsible for the category Cheese. The scope of this research specifies under this cluster.

1.5 Locations

Within the FrieslandCampina company, there are multiple cheese packaging locations in Europe. These locations are Wolvega, Leerdam, Lochem, Dortmund, Senas, Las Palmas and Genk. Dortmund, Senas and Las Palmas are locations with a relatively low capacity. The packaging location in Genk has got an average capacity. Wolvega and Leerdam have the highest capacity. This capacity is 10 to 20 times larger than the capacity of Dortmund, Senas and Las Palmas. Since the location in Lochem has been closed, its production is being moved to Wolvega and Genk, which increases the gap between the smaller and larger locations.

Wolvega is mainly specialized in rectangular cheese slices in reclose, duohard and flowpack packaging. In addition to slices, the location produces vacuum deepdraw and reclose packaging for square blocks of cheese. (packaging types will be explained further on)

Leerdam packs wedges (parts of a round wheel of cheese) with vacuum deepdraw and flowpack packaging. Also, wedges of round Edammer balls are packed with vacuum deepdraw packaging. In addition to smaller portions, whole Edammers, whole wheels of cheese and elongated loaf shaped cheeses are packed in carton boxes.

Genk is specialized in slices of cheese wheels and rectangular cheeses, packed in reclose packaging, wedges in vacuum deepdraw packaging and grated cheese in flowpack packaging.

Senas packs wedges of Edammer balls in vacuum deepdraw packaging. Also slices and snack sized blocks of Edammer are packed in reclose and flowpack packaging.

Dortmund packs slices in flowpack packaging and blocks in vacuum deepdraw packaging.

Las Palmas has a small packaging production for sliced cheese.

The production in Lochem of duohard packed slices of rectangular cheese, reclose packed slices of rectangular cheese and big packs with slices for the food service industry is transferred to Wolvega. The production in Lochem of reclose packaging of rounded slices, vacuum deepdraw packaging of wedges, flowpack packaging of snack sized blocks, slices and grated cheese is transferred to Genk

Image 7: Thermoform packaging line.

Since square cheeses are the easiest to automate, Wolvega has been the most automated plant. Because of the high amount of automation in the packaging process, Wolvega was chosen as focus for this investigation.

1.6 Motive

The current cheese packaging process consists of various types of cheeses and brands. This results in a lot of different printed packs, which makes it a costly and complex process. The supply chain management of the cheese packaging factories requested a less complex packaging system, which can be monitored more easily and be more efficient.

FrieslandCampina figured that different printed packaging can be put through a more uniform packaging line, with a customisation step at the end of the process. FrieslandCampina is convinced that late stage customization can increase supply chain efficiency and can result in cost reduction.

Due to the increased length of packaging lines (from 25 to 55 meters in the last couple of years), switching between orders is very time consuming. During this changeover time, the production line has to be stopped. This results in less efficient production lines and packaging material losses. For now, the order size needs to be at least 5 times as long as the change over time to be profitable. Therefore orders have to be large, and the production becomes less flexible in producing smaller orders.

The Global Packaging Development team did not have the excess time to research these possibilities. This is why it was set out to be a research conducted by a student intern. This way, the needed amount of effort could be put in the research of the possibilities.

1.7 Research Question

1.7.1 Research description

The research description before starting was:

"Late stage customization Cheese packaging: FrieslandCampina is convinced that late stage customization can increase Supply Chain efficiency and can result in cost reduction. Due to that a

multidisciplinary project team Chameleon has been started with the first initiative to implement in-line printing of (unprinted) outer cartons within baby food production.
The aim of this study is to investigate and report the opportunities for late stage customization of primary and secondary packaging within the Cheese packaging factories from R&D perspective. It's expected that (at least) two feasibility studies are reported: one in cartons and one in foil."

After a meeting with the manufacturing director of FrieslandCampina, the goal of the research was redefined to the following:

Due to the growing length of packaging lines, switching between orders takes up longer periods of time. For now the order size needs to be at least five times as long as the changeover time to be profitable. Switching to another foil on a line of 55 meters at the end of an order takes too long and results in high material waste. This makes smaller orders inefficient. Having a late stage customization step can make smaller orders financially attractive.

Jumbo reels of unprinted deepdraw bottom foil are already a common practice. In the best scenario, jumbo reels of unprinted foil replace the current printed top foils.

Ideally, the customization step takes place after sealing the cheeses. This way the system is highly flexible.

The scope for applicable technologies for long- and short term options should be as wide as possible. In this case, short term means applicable within 1,5 years and long term means applicable after 1,5 years.

The first focus for investigation is on Wolvega, because this location is highly standardized.

The goals are:

- Cost reduction by increased line efficiency (lower price per kg of cheese).
- Prevent obsolete packaging material.
- Increase production flexibility.

1.7.2 Added value of late stage customization

Adapting the current cheese packaging process with the possibility of late stage customization can increase flexibility, reduce waste and create more revenue. The increase in flexibility creates play for the company's brands and private labels to further pursue the increase of value of their products. Having more flexibility also creates the possibility for more streamlined connection between the brand and the consumer by having a faster time to market. Reducing waste is consistent with the reduction of CO^2 emissions and the sustainable production stated in the CSR Strategy House and the ambitions of FrieslandCampina, which can be found in Appendix A.

1.7.3 Research question + Reading guide

The adapted research description resulted in the research question and its sub-questions. To show an overview of the locations of the answers of the sub-questions, a reading guide was created.

The research question and the reading guide are shown below. The research question with the complete list of sub-questions can be seen in Appendix B.

The research question:

Which late stage customization steps can be implemented in the cheese packaging lines of Wolvega to increase line efficiency, prevent obsolete packaging material and increase production flexibility?

The reading guide below shows which answers to the sub-questions are addressed for each chapter.

Chapter 2 gives an analysis of the current process.

Chapter 2.1 covers the current setup of Wolvega and how much floor space is available.

Chapter 2.2 explains the currently produced packaging types.

Chapter 2.3 gives a step by step view on the total packaging process.

Chapter 2.4 addresses the current issues that need to be solved.

Chapter 3 combines the insights found in chapter 2 to create a subdivision of requirements.

Chapter 3.1 explains the current restrictions that a customization step must abide to.

Chapter 3.2 gives the solution space which has a positive effect on the possibilities.

Chapter 4 describes possible solutions for implementation.

Chapter 4.1 addresses the directions in which solutions can be implemented.

Chapter 4.2 explains the current printing techniques and their characteristics.

Chapter 4.3 addresses the possibilities for changed appearance solutions.

Chapter 4.4 addresses the different requirements for foils, labels and boxes.

Chapter 4.5 reviews the possibilities and reports the suitability of the options.

Chapter 4.6 addresses the digital printing machines.

Chapter 5 evaluates the findings of chapter 4 to create recommendations on which late stage customization steps are possibilities

Chapter 5.1 gives feasible long- and short term options applicable for Wolvega

Chapter 5.2 states the conclusions of this research

Chapter 5.3 gives recommendations on future steps

Chapter 5.4 opens a discussion on the quality of the research

2- Process

As stated before, the focus of this research is on the packaging plant Wolvega. The following information will be a description of this packaging plant and its processes. Although the other locations are not mentioned in this part, a lot of similar processes can be found there.

2.1 Floor space

The increasing amount of produced packs and adoption of packaging lines of Leerdam, results in a limited floor space. There are 17 packaging lines at Wolvega, which have increased in length. An overview of the floor plan of Wolvega can be seen in appendix C.

The location consists of a few main divisions, these being the arrival storage, pre-processing, two packaging locations, material storage and chilled departure storage.

The arrival storage and the chilled departure storage consist fluctuating amounts of inventory. The material storage is jam-packed with materials with little room for more materials. The pre-processing and the two packaging locations are well equipped with packaging lines with no room for extra packaging lines.

This means that an increase of capacity for Wolvega depends on an increase of capacity for the existing packaging lines through adaption or replacement or a restructuring of the building to increase more floor space for more packaging lines.

The last option is not only costly because of the costs of reconstruction the building but extremely costly because of the halt in production during the reconstruction. This option is therefore avoided. Increasing the capacity should come through innovation of the packaging lines.

2.2 Packaging types

There is a variety of materials used for creating the different types of packaging. The primary packaging use different types of plastics to create barriers between the cheese inside of the packaging and the surrounding influences during storage and transportation. (standard packaging materials and their properties are explained in chapter 3.1.1)

These plastics are PET mono material and multi-layer plastic foils. The different materials used in different packaging foils can be seen in the overview of appendix D. The different types of packaging materials used for the primary packaging are pre-formed trays, pre formed lids, bottom foils, top foils and labels. The secondary packaging consists of a corrugated carton box and a label and the tertiary packaging contains of a pallet, stretch foil and a label.

Bottom foils for packaging are transported on jumbo reels. These foils are more rigid than the top foils. The flexible top foils are stored on reels with a smaller diameter.

There are a lot of different packed products within the packaging plant at Wolvega. These products are categorized in different types of cheese packaging and different keylines. These different types of cheeses packaging divide the products by packaging type. These packaging types each have their own characteristics and production method. Some of these production methods are similar and can be performed on the same packaging lines. These packaging lines are linked to corresponding keylines, which contain the requirements of the prints. These keylines give a view on the differentiation of required prints for the top foils needed for these types of cheese packaging.

Keylines contain the following specifications:

- Size of foil used per packaging
- Foil reel width
- Foil materials

- Winding method
- The corresponding packaging lines
- The used printing technique
- The number of used colours for the printed design
- Design and text area locations on the foil
- Locations on the foil with restricted design possibilities due to sealing areas
- Transparent locations on the foil

Different keylines of Wolvega are shown in appendix E.

The reels of plastic foil are stored in the warehouse. When a new reel of foil is required in a packaging line, it is transported from the warehouse to the corresponding packaging line. Here, the reels get mounted on carriers located above and beneath the conveyor belts. The reels that contain top foils, which are mounted above the conveyor belts, have a smaller diameter. Although the personnel responsible for this task do not have to lift the reels by hand, the reels have to be limited in size because of the structural integrity of the carriers. The reels that contain bottom foils are called jumbo reels. These reels are larger in diameter and are mounted on carriers which can withstand a higher load. Some production lines produce packaging that only uses one reel of foil, which will be explained hereafter.

The different types of cheese packaging are: Reclose, Duo hard, Vacuum deepdraw, Pre-formed tray, Portion packs, Freshlock and Non-reclose. Vacuum deepdraw contains flat pieces. Reclose, Duo hard and Pre-formed trays contain flat pieces or slices. Portion packs contain 1 or 2 slices. Freshlock contains slices, and non-reclose contains a larger amount of slices.

A schematic view on this subdivision can be seen below in image 8. An overview of the different products can be found in appendix F, an overview of the types and keylines can be found in appendix G.

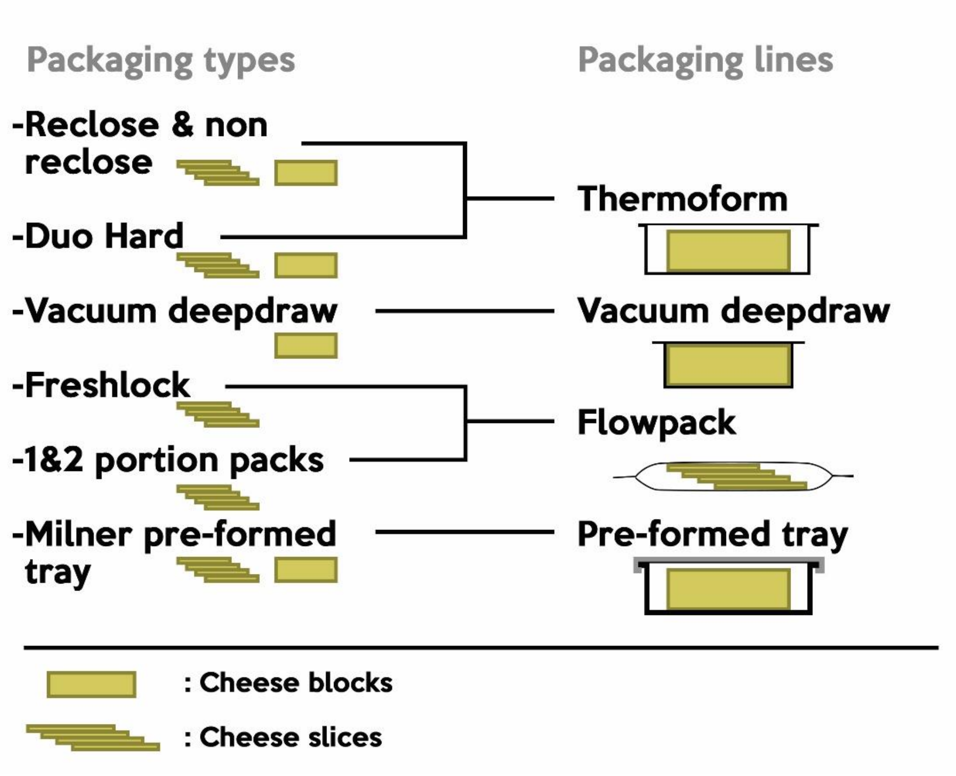

Image 8: Subdivision of packaging lines.

- **Reclose** is packaging with a thermoformed plastic tray and a thin plastic top foil which is sealed around the edges. The pack has a glue layer incorporated in the topfoil, which is the layer on which the pack tears open when opened by a consumer. This controlled tearing applies only to the sealed edge. After initial opening of the seal, the pack can be reclosed with the use of this glue strip, preventing the cheese inside from drying out.
- **Duo hard** is basically the same as Reclose packaging, but instead of a thin plastic top foil, it has a thermoformed thicker cover, made from thicker foil, which clicks into the tray. Reclosing is not obtained by glue, but by the thermoform construction of the pack.
- **Vacuum deepdraw** uses thinner plastic foil which is vacuum formed around the cheese. One side protrudes from this pack to have an edge which is sealed. This side of the pack uses printed foil and is considered the top of the pack.
- **Pre-formed trays** are not manufactured at Wolvega, but are bought elsewhere. This pack contains a thermoformed tray and an injection molded cover with an inmould label. The tray and the cover click together rigidly. To insure the shelf life, an additional thin unprinted plastic multilayer foil is sealed to the tray after the cheese has been put in.
- **Portion packs** are flowpacks, made from a single reel of flexible foil. This foil is folded around the cheese and sealed to itself lengthwise and sealed at the two remaining sides. (Flowpacks are further explained in chapter 2.3.3.)
- **Freshlock** is an envelope shaped flowpack which is sealed on three sides. This 3-sided seal contains one peelable seal as well as a hook and loop zipper, which enables reclosure of the pack.
- **Non-Reclose** packaging is basically the same as Reclose packaging, but has no glue layer added to the topfoil. After the packaging has been opened, it cannot be reclosed.

Image 9: Examples from left to right: Reclose/non-Reclose, Duo hard, Vacuum deepdraw, Preformed trays, Portion packs and Freshlock.

The pre formed tray will in time be replaced by a new Version of Freshlock.

As seen in image 8, some packaging types are grouped in single production lines, since they have a similar production technique. The production lines are called Form Fill Seal, Vacuum deepdraw, Flowpack and Traysealers. The production method of each of these production lines is explained in chapter 2.3.3.

2.3 Total Process

The overview in appendix H shows the process of Wolvega. In this overview, the packaging step is globalized to the steps: 7.Verpakken, 8. Inpakken and 9. Palletiseren, wrappen en/of strappen. These steps are further elaborated in this chapter.

2.3.1 Pre-processing

At Wolvega semi-hard rectangle cheeses are cut and packed. Cheeses are delivered from the production and ripening plants to the packaging plant at the correct commercial age. These are naturally ripened or foil ripened rectangular pieces of cheese with a dimension of 50 x 30 x 11 cm. These cheeses arrive on wooden planks which are transported on steel racks, or arrive stacked directly on top of each other on boxed-in-pallets. These boxed-in-pallets fit tightly around the stacked cheeses preventing the cheeses from bulking. An example of arriving naturally ripened cheese can be seen in image 10.

After delivery of the cheeses, they are received and stored in warehouses. The receiving process can be manual or automated. Depending on the final product, the cheese will require pre-processing. In the case of foil protected cheeses, these cheeses are defoiled by hand or by an automated machine. In case of natural ripened cheese, the cheese is de-rinded in an automated machine, or by hand. After pre-processing the cheese will be stored again.

Bron: Production Supply, field research, FrieslandCampina Summit. 23 may 2013 authors: Joost Gijsbers, Yulison Tri Gunawan (Sonny)(pagina 22)

Once the cheeses are transported to a temporary storage, the wooden planks are washed and are gathered for transport back to the cheese factories.

The de-rinded cheeses are then transported by plastic crates and put into an intermediate storage. After this intermediate storage, the cheese is transported to the cheese cutting area. The cheeses are transferred from the crates to a conveyor belt. The crates are then transported to a washing station, where they are cleaned and dried for re-use.

Image 10: Naturally ripened cheese in arrival storage.

2.3.2 Cheese cutting

In the cheese cutting area, the cheeses are cut lengthwise to create a loaf shape. These loaves are then cut into specific sized pieces on some of the cutting lines, and cut into slices on other lines. The cutting of pieces uses a laser guided cutter to create pieces with a fixed weight. These pieces are automatically weighed during this part of the process. The first and last part of the loaf is of insufficient size. These pieces are separated from the regular process and dropped into a container. These parts are used for other purposes, like grated cheese. A production line which slices cheese uses a slicer machine to cut the loaves into slices. These slices are then imbricated with the use of the cutting speed of the slicer and the speed of the conveyor belt. This creates separated and slightly shifted stacks of cheese slices. The slices can be interleaved, which separates the slices with intermediate leaves to make the separate slices release easily by the consumer. An example of cheese cutting is shown in image 11.

Image 11: Cheese cutting.

2.3.3 Packaging lines

These pieces or slices are then transported to the packaging part of the line. The different types of lines are Form Fill Seal, vacuum deepdraw, flowpack and Traysealers, which are explained below. This part of the production line creates the primary packaging, which is the packaging you see in the supermarket.

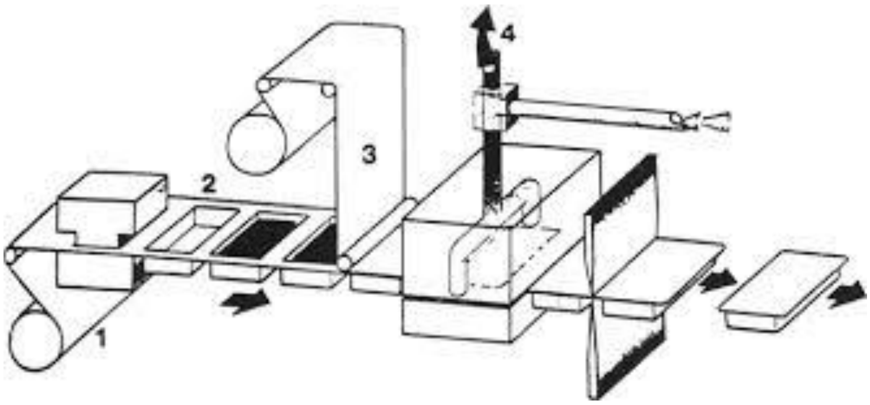

Image 12: Form Fill Seal production.

-**Form Fill Seal lines(image 12)** produce Reclose, Non Reclose and Duo Hard packaging. These packs have a thermoformed tray which is made by pre-heated bottom foil which is formed in a mold(1). These machines create sixteen tray shapes at a time, containing four rows of four trays. The cheese is dropped into these trays(2) with the use of four conveyor belts. When the cheese is placed in the trays, a pre-printed foil is transported by reels atop of these trays(3), and is sealed to the edges of these trays. During this sealing process, the air surrounding the cheese in the trays is removed with a vacuum(4). A mixture of carbon dioxide and nitrogen is then added, right before the tray is sealed to increase the shelf life of the cheese. This is called MAP(Modified Atmosphere Packaging). Depending on the design, the packaging gets a bottom label, a top label and sometimes even a promotional label. These sealed trays are then separated by cutting them perpendicular between trays and then cutting them lengthwise by rotating blades. The individual packs are then put through a seal inspection.

-**Vacuum deepdraw lines** produce vacuum deepdraw packaging, which use a similar line set-up as a Form Fill Seal line. The difference is that the bottom foil of this packaging type is much thinner, making it more flexible and affected by heat. This makes it possible to vacuum the packs around the cheese instead of having a rigid tray. The step of vacuuming the air in the packs, as seen in Form Fill Seal lines is replaced by vacuuming the bottom foil around the cheese to the top foil before sealing them together.

-**Flowpack lines** (image 13) can produce Freshlock and portion packs. These packs are made from a single reel of flexible foil. The packs in these lines are created individually instead of sixteen at a time. The foil is folded around the cheese and sealed lenghtwise. The seals between packs are sealed at the same time as the air in the packs is vacuumed, and a mixture of carbon dioxide and nitrogen added. Cutting flowpack packaging happens simultaneously to sealing and vacuuming. They then get a label put on the bottom. The seal of the packs is verified afterwards.

Image 13: Flowpack line.

-**Traysealers** produce preformed tray packaging and use thermoformed trays and injection moulded lids with inmould labels. These rigid trays and lids are produced at a packaging supplier, and transported from storage to the packaging line. The cheese pieces or slices are dropped automatically from conveyor belts into trays. These trays are individually sealed with a thin transparent foil and the air is also vacuumed and replaced with a mixture of carbon dioxide and nitrogen. The seal is then checked and the rigid cover is clicked onto the tray. Afterwards, a backlabel and sometimes a promotional label are added.

In the case of the Form Fill Seal, the Vacuum deepdraw and the trayseal lines, the packs are produces in four rows at a time. An in-liner then merges these rows to create one conveyor belt with individual packs. Before heading to the next step in the process, the packs are checked by a metal detection machine.

2.3.4 stacking and shipping

When the individual packs are created and checked, they are transported to the stacking and shipping part of the process, where they receive their secondary and teriary packaging. The secondary packaging is used for transportation which are boxes created in-line from sheets of carton. These are formed and hot glued automatically. The primary packaging gets stacked into these boxes and is closed. A label is then added to the side of the box. This secondary packaging is used as SRP(Shelf Ready Packaging) in some cases.

These boxes are transferred to a palletizer which stacks the boxes using a robotic arm. There is one palletizer per two packaging lines because of the overcapacity of a robotic palletizer. After the pallet has been fully stacked, it is transported to the wrapping machine. This wraps the pallet in stretchfoil.

These stacked and wrapped pallets are then transported to a chilled storage or directly loaded into a truck, which transports it to a distribution centres. The total process of the cheese from being delivered at Wolvega to the start of the distribution will take approximately 24—72h. (Gijsbers, 2013)

The speeds in which the different packaging lines operate is shown in appendix J

2.4 Issue

This process results in the current issues previously discussed in the research description. These are obsolete packaging materials, long changeover times, financially inefficient short runs and limited flexibility.

2.4.1 Storage

Because there are a so many different configurations that can be put through the packaging lines of Wolvega, there is a need for a large amount of different packaging materials. There is a total of 39 different types of cheese packs at Wolvega as seen in appendix F. These cheeses have different ages, weights and retail brands. Each of those factors contributes to the amount of different packaging materials that are needed in the current process. Different countries for instance demand different printed foils and labels because of difference in language. Different ages or weights require a different print design. This results in a large amount of different labels and foils. These are called SKU's(stock keeping units)

The current amount of SKU's can be seen in appendix K

For each of these SKU's there has to be a sufficient amount of packaging material in stock. This originates from the demand for long runs. The order time for new or existing reels also contributes to the amount of foil and labels needed in the locations storage.

This demand for a high amount of stock in combination with a packed material storage results in a lack of storage space for the current process.

2.4.2 Flexibility

As stated before, there are long order times for printed foils. These delivery times increase the amount of storage space needed as well as increase the time to market for new product designs. New product designs can be driven by regulations, which demand new information displayed on labels, but can also be driven by a new shape of a current packaging design, a new brand identity or other marketing needs that require a change in appearance.

Long delivery times therefore lower the flexibility for new designs in longer of shorter runs. However, they do not change the flexibility in the length of runs. This is determined by the changeover times. The need for more flexibility comes from the demand for short runs and the long production lines which make these short runs financially inefficient. Having small sized runs is not a feasible option with the current process.

There is no demand for individualisation of primary packaging, linked to personal preferences for cheese. Personal individualisation in the packaging world is growing, but mostly for products with a longer, uncooled shelf life. Examples of this are promotions by CocaCola, Nutella, and Budweiser. (Roderick, 2015) (Monllos, 2015) (Roberts, 2016).

The demanded individualization comes from the demand for financially efficient short runs. Creating a process where a change in appearance of packaging does not, or has little, effect on the changeover time creates more revenue and flexibility.

2.4.3 Obsolete materials

Having a demand for a new appearance by either marketing, a new type of packaging or the information that needs to be displayed by changing regulations makes the previously printed labels and foils obsolete. Since the printed design is no longer up to date and will not be used from that moment on, it will just take up valuable storage space and it eventually will be discarded. This is an unnecessary waste of material and results in extra costs.

Having a standard in the length of foils on a reel creates another problem for the discarding of materials. Due to high running lengths, and long production lines, stopping the whole production line to change a reel of foil is financially unattractive. This is why not all small, unfinished reels from previous runs are reused. The costs of not running the production line outweigh the material costs.

This means that some used foil reels, which have a print which is still usable, are obsolete and discarded.

The amount of extra costs in the case of Wolvega can be seen in Appendix K

2.4.4 Changeover time

The changeover time is the time needed to switch between different foils and labels with different prints when the type of cheese, or language, that runs on a packaging line is changed. The effect of the changeover time increases with the length of the packaging line. Since the packaging lines have increased in length for the past couple of years the effect of the changeover time has increased as well(Manufacturing director of FrieslandCampina).

Changeover times are part of the reduction in OEE(overall equipment effectiveness) of the production lines. The OEE consists of short stops, changeover, organizational changes, speed losses, technical restriction and quality restriction.

The maximum operating speeds in combination with operational hours of the packaging plant determine the line capacities. The information on line capacities can be found in appendix J.

The amount of runtime, the loss due to each part of the OEE and the need for changeover per amount of packaging material can be seen in appendix K

3- Restrictions and Solution space

This chapter addresses the restrictions and the solution space of the research. The restrictions are the barriers that confine the solution space and determine the requirements for possible implementation. The solution space consists of enablers that create possibilities. These possibilities are case specific.

3.1 Restrictions

There are many different restrictions that need to be kept in mind when you are looking for new methods to implement in a process. In this chapter, the restricting dimensions of the current process are discussed. These dimensions are: Material influences, high care zone, print size, print speed, print quality, costs and food and safety legislations. These dimensions determine the shelf life, the brand appearance, the profitability and the safety of the packed cheese.

The barrier properties of the pack prevent oxygen and moisture from entering. These barriers are of great importance, since these affect the quality of the cheese, and therefore the shelf life (Flair, 2016).When hard cheese is cut into pieces or slices, organisms get the chance to grow on the sliced edges. The growing of these organisms can be resisted with the use of a vacuumed pack, or a pack with a protecting atmosphere of at least 30% CO^2. The other 70% or less is filled with N^2 to prevent deformation of the pack. Cheese without this atmosphere would only be preservable for one or two weeks. The MAP prolongs this shelf life to at least three months. This shelf life is determined by the intrinsic value of the cheese, which degrades over time. After three months, the quality of the taste is not representing the brand well enough to sell it. The prevention of mold growth, using this MAP, is prolonged by an even longer period (Ten Klooster R. e., 2008).

The effect a possible late stage customization solution has on these factors will be taken into account. However, the shelf life is also affected by the production- and shipping environment. The supply chain subject the packaging to a chilled environment during transport of 2-7 degrees Celcius and a controlled humidity of 50-80%. In this supply chain, the packaging can a be handled a certain amount of times, which will affect the quality of secondary packaging and the height of stacked boxes per pallet (Romanik, 2016). In this research, the production environment will be taken into account through the impacts of possible solutions. An in depth research on the production and shipping environment is not part of the scope of this research.

3.1.1 Material influences

Material influences can be split into two groups: Direct contact material influences, and indirect contact material influences. Direct contact material influences are the influences created due to the direct contact between the material and the cheese. This is for instance the tray of the packaging, on which the cheese rests, but also the inside of the top foil of the packaging when the cheese touches the top foil. Indirect contact materials are materials that do not get into direct contact with the cheese. These materials can however influence the cheese trough migration.

The influence of indirect contact materials is mainly determined by the amount of migration the direct contact materials allow. Migration is the interactivity that occurs between the container wall and the packed product. Migration is a physico-chemical occurance. Positive migration, in short migration, means that the components of the container wall will transfer to the cheese. Negative migration is the transfer of components from the cheese through the container wall (Ten Klooster R. e., 2008).

The different migration types are explained in image 14.

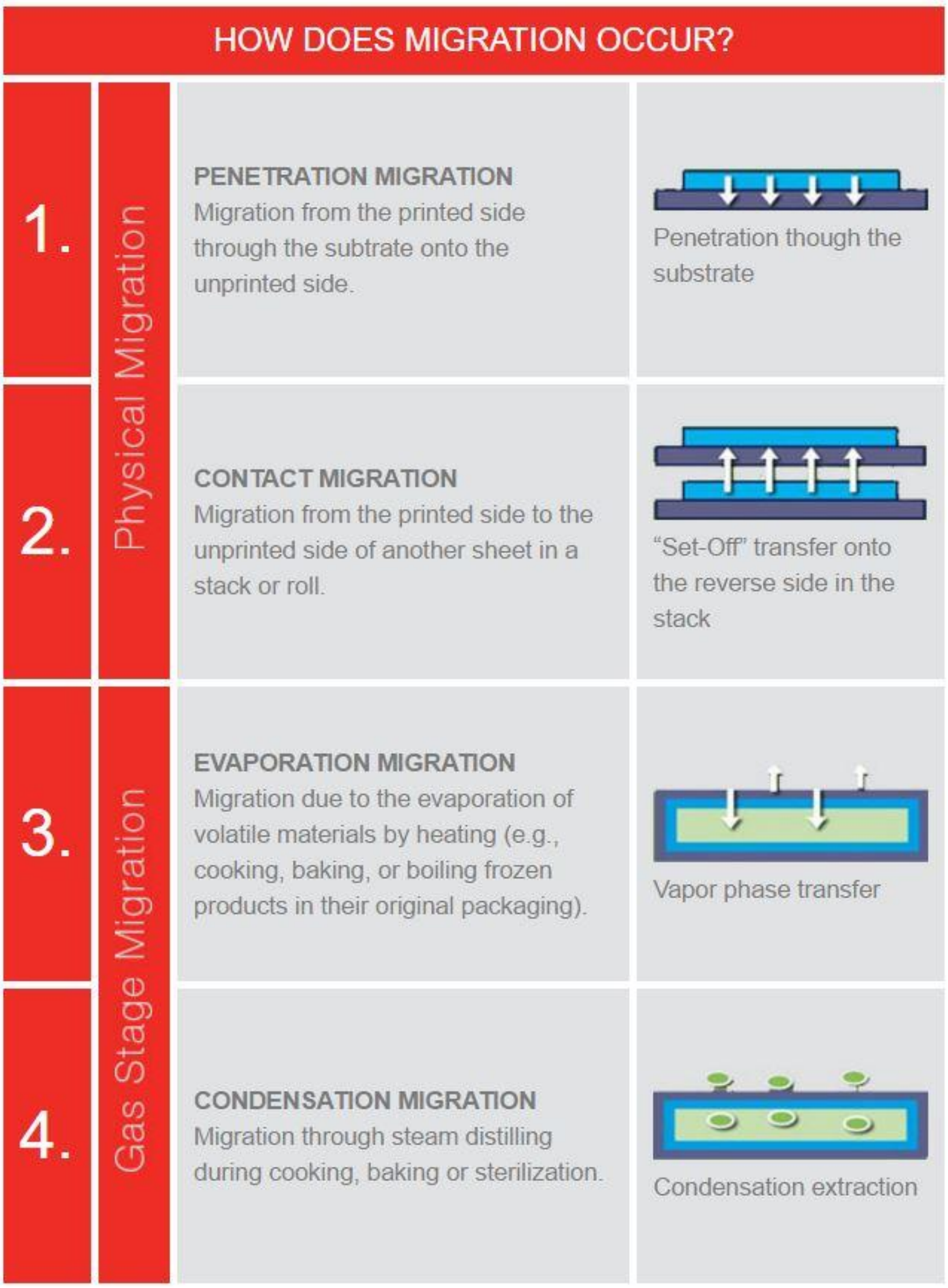

Image 14: Migration types.

Migration is influenced by the substance itself, the type of material, the type of food and the conditions like temperature and the duration of exposure (EFSA, 2016).

Some materials are better barriers than others against specific migration. The migration that affects the shelf life of cheese in normal conditions is water vapor, light and oxygen. (Normal conditions exclude extreme situations with hazardous indirect contact materials like lead or radioactive materials.)

Light and residual oxygen leads to the oxidation of fats, which contributes to "off" flavors in the cheese. Reducing head-space volume and minimizing residual oxygen are both important to increasing the shelf life of cheese (Flair, 2016).

This technique has been implemented at Wolvega. Also development in using thinner multi-layer foils creates the need for research on the effect of a new customization step on the thin barriers of the foil.

Examples of multi-layer foils can be seen in image 15.

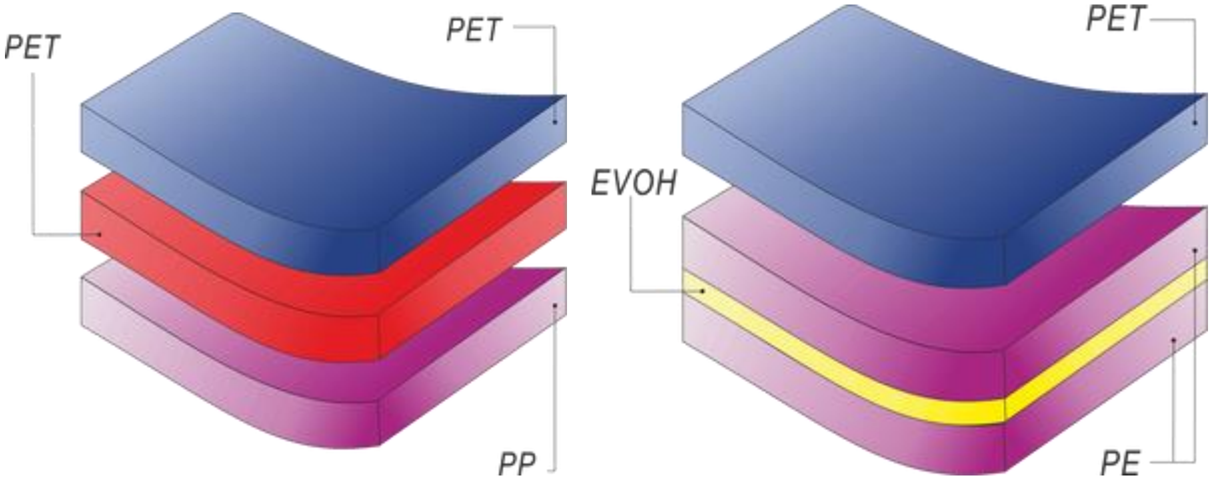

Image 15: Multi-layer foils.

The currently used packaging materials can be seen in appendix D.

Commonly used materials for flexible films, and their properties are explained briefly hereafter to give a view on the barrier properties of each type of plastic. These plastics can be extruded in one direction to create a cast film and extruded in two directions to create oriented blown films.

PE - Polyethylene is a family of addition polymers based on ethylene. It can have different densities based on its structure.

PP - Polypropylene has a higher melting point, and thus better temperature resistance, than PE.

PET - Polyester (Polyethylene Terephthalate) is a tough, temperature resistant polymer. Biaxially oriented PET film is used in laminates for packaging where it provides strength, stiffness, and temperature resistance. It is usually combined with other films for heat-sealability and improved barrier properties. However, FrieslandCampina uses a lot of mono-material PET.

EVOH - Ethylene-Vinyl Alcohol copolymer is used in coextruded plastic films to improve oxygen barrier properties. It is, however, a poor water vapor barrier. Even its otherwise excellent OTR (oxygen transmission rate) is sensitive to high humidity. Therefore, for packaging applications, it is usually the core layer of co-extruded plastic films where it is shielded from moisture by protective layers of polyethylene. Its OTR also depends on its VOH (vinyl alcohol) content.

LDPE - Low density polyethylene is used mainly for heatsealability and in bulk packaging.

LLDPE - Linear low density polyethylene is tougher than LDPE and has better heat-seal strength. LLDPE has higher haze than LDPE.

Nylon, mostly referred to as PA(Polyamide) or OPA(Oriented Polyamide) - The nylon family is made up of polyamide resins with very high melting points, excellent clarity, and stiffness. Two types are used for films: nylon-6 and nylon-66. The latter has much higher melt temperature thus a better temperature resistance, but the former is easier to process and is less expensive. Both have good oxygen and aroma barrier properties, but they are poor barriers to water vapor. In addition, nylon films can be cast (Flair, 2016).

3.1.2 High care zone

Indirect contact material influences due to exposure of the cheese during the packaging process are also important. That is why the part of Wolvega where the cheese is openly exposed is a restricted area, which is also called a high care zone.

The floor plan and material routing of Wolvega can be seen in attachment Layout KVPC. This floor plan shows different types of care required in different parts of the buiding. Throughout the building, there is a basic care, which requires the need of a lab coat, specialised shoes and a hairnet and if applicable, an additional one to cover a beard. An example of the hairnets is shown in image 16. The pre-processing area (called "voorbewerking" in the overview) is a medium care zone, due to the exposure of cheese. The need for higher care at the pre-processing is especially needed where the rind gets peeled off manually. The restricted area is the area where the cheese is exposed for a longer period of time, divided into smaller blocks or cut into slices. Then these blocks or slices are transported and sealed into their packaging. After the packaging have been sealed and cut into individual packs, the restricted area ends, and the packaging is transported to the basic care area. In the medium care area and the restricted area, an additional hygiene check is mandatory to enter.

Image 16: Safety preparations.

There are certain standards which have to be uphold in a high care zone. High care areas require high levels of hygiene, working practices, fabrication, design of facilities and equipment to minimise product contamination with regard to microbiological hazards.

The main standards of a high care zone to prevent contamination are the following

The segregating barrier between the high care zone and a zone with a low or medium care must be capable of preventing the risk of cross contamination from:

- All people moving between the high-risk area and other areas except through designated changing areas.
- The movement of all equipment, utensils or materials into the high risk area except through designated ports with sanitising controls in place.
- Water or other liquids on the floor, washing into the high risk area.
- Air borne contaminants e.g. dust particles or water droplets.

To prevent air borne contaminants from entering a high care zone, it needs to maintain positive pressure compared to adjacent areas, particularly where there is an interface with low risk areas.

Designated changing areas must:

- apply specific dedicated protective clothing (i.e. not worn in other areas of the factory)

- use visually distinct protective clothing (e.g. different colour or style) including clean overalls, headwear and footwear
- apply clothing in a given order (e.g. hairnet first, then shoes, wash hands then put on protective overall)
- wash hands during the changing procedure
  (BRC, 2012)

These are not all requirements for a high care zone but give insight in the effort that is put into preventing contaminations from entering the cheese.

3.1.3 Print size

The implementation of a late stage customization step must be cost effective. One way of being cost effective is to have little impact on the current process. When a process is greatly influenced by a change, multiple parts of that process need to be replaced which result in unwanted expenses. The print size is a good example of this. The current packaging requires a certain size of printed foil. The current machine setup can add to this requirement in the case of Form Fill Seal and vacuum deepdraw production lines. These lines create four rows of packaging simultaneously which requires the width of the printed foils to be nearly four times as wide. Replacing the currently pre-printed foils with an alternative customization step requires this new process step to be as effective as the current printed foils. This means that this customization step must also be able to apply the information on four rows at the same time or on the same width as the four rows combined. Another possibility is printing on the foil after the packs have been separated from each other. This requires a smaller print surface, but higher speeds. However, if there is a possibility which uses a different print size to display the same amount of information, therefore altering the currently used machines of the process, this change in machines must be taken into account. This change in machines can result in a large amount of implementation costs. This will affect the cost restriction mentioned below.

3.1.4 Speed

The product demand will only increases due to an increasing world population, welfare and consumer preference for nutritious food, which will increase sales. This increase in sales leads to a higher demand of the production, and therefore the packaging lines. This means that the speed of the new implementation must be equal or greater to the current speed of the process. Each new added machine that is part of the production line should not be the bottleneck of the system, but create a future possibility for faster run times and more efficiency. The demand for increased effectiveness of the packaging lines also increases due to the lack of floor space in the factory.

The potential and current running speeds of the packaging lines can be seen in appendix J.

3.1.5 Print Quality

The print quality of the new implementation must be equal or an improvement to the current quality of the printed foils. This print quality is defined by the possibilities of the suppliers of the printed foils. There are two main suppliers. The print quality they can deliver is shown below as well as an example of a rotogravure press which is shown in image 17. This is not the same quality that is demanded by FrieslandCampina. This demanded quality is shown in appendix K. The quality of a new implementation should be equal or greater to this demanded quality, not the possible quality that can be delivered. It is however wise to keep in mind that extra quality options current suppliers can facilitate can weigh in favour of not implementing a new process step which is not able to deliver that same quality.

Supplier 1:

- Registered printing of front and back, including inline lamination in rotogravure up to 12 colours
- High-quality flexo printing up to 10 colours
- Digital print with possibility of individualization and personalization

- Matt varnish, lacquer, matt/gloss combination, haptics lacquer and printing of paper and fleece effects
- Intermediate layer and surface printing
- Continuous printing of EAN codes on rigid films

Supplier 2:

- 11 colour print with high-tech rotogravure machines with print widths up to 1380mm.
- Cold seal, lacquer and also inline lamination applications are available
- High-quality flexo printing up to 10 colours with print widths up to 1570mm
- 3 separate in house ink-dispensing systems for flexo and rotogravure, which ensures that the best possible colour results are achieved and create colour consistency throughout repeated orders is created.
- Both solvent based and solventless lamination alternatives are possible.

Image 17: Rotogravure press.

3.1.6 Costs

The costs of a new implementation should be proportional to the added value of the change. If the quality of the individualization is less than the current print, the time to market of a new design faster, and the cost per product increase, the company has to decide if the faster time to market weigh up to the added costs and lower quality. This however is subjected to the interpretation of the company. Costs are the main aspect in determining if a implementation can be applicable. The current profits depend on low price per pack. If these costs are increased with the use of a new method, it will probably not be implemented. However if a new method creates a faster time to market for products, it can lead to added sales and revenue. If these indirect profits exceed the increase in production costs for the packaging, the method is financially attractive for FrieslandCampina.

When a new implementation requires the entire packaging line to adapt to it, the costs will increase immensely. Therefore the base of the implementation must not affect the production speed of the entire chain as well as not influence too much change to other parts of the packaging line.

3.1.7 Food and safety legislations

The cheese that is packed at Wolvega is shipped all across the world. This means that the food and safety legislations of all the countries to which the cheeses get shipped must be uphold. There are overarching food and safety legislations and additional local food and safety regulations determined by the local government. The largest overarching food and safety legislations are determined by the following:

The Food Safety Modernization Act (FSMA) in the United States of America

The Safe Food for Canadians Act (SFCA) in Canada

The European Food Safety Authority (EFSA) in Europe

Food Standards Australia New Zealand in Australia and New Zealand

The National Food Safety and Quality Service in Argentina

The National Agency of Sanitary Surveillance (ANVISA) of Brazil

The China Food and Drug Administration (CFDA) of China

(GFSR, 2016)

Governments of Western Europe have the highest requirements in food safety. The Netherlands and Switzerland are known to have the highest requirements of them all.

Since the cheese packaging factory is stationed in the Netherlands, FrieslandCampina has to abide to the European laws as well as those of the Netherlands. FrieslandCampina has their own Declaration of Compliance for Food Contact Materials which has to be signed for all food packaging materials by the suppliers. This declaration includes basic EU legal compliance and additional national legal compliance and can be seen in appendix L. With having the packaging factory located in a place where the requirements are highest has its advantages. The cheese packaging abides to one of the strongest regulations, and therefore most of the world. This means that food regulation abidance in foreign countries are no big obstacle.

The legislations contain all different sorts of migration issues. When for instance a new implementation applies ink to the packaging foil, The ink has to uphold the EuPIA guideline for food packaging inks (EuPIA, 2012).

Many factors are driving change in the food industry, not the least of which is impending new

regulatory requirements that are part of the FSMA or the EFSA. Changing regulations can require different information to be displayed on food packaging as well as diminish the use of certain materials. When the current packaging materials or displayed information does not uphold these requirements, the material or the design has to be changed, leading to more obsolete materials (Romanik, 2016).

There are many aspects to food packaging and the recycling of materials. Everyday there are tests being executed to know which materials are harmful and should not be into direct contact with food. Testing also continues on recycled materials and possible harmful particles that are concealed within these recycled materials. This leads to ever changing rules and regulations for food packaging. Ink oddments in recycled plastics are under investigation by the Food Standards Agency (FSA). Inks that are used as indirect food contact materials will be incorporated in the plastics when packaging is recycled. These plastics could then be used as direct contact materials. The FSA planned to launch the regulation on the amount of ink oddments and their safety hazard in 2013 and add it to the 1935-2004 European food contact regulations (Borrell Fontelles, 2004). The research on these hazardous ink oddments was started in 2008 and is still not finalized. This means that possible hazards are not regulated yet, but might be in the near future.(NVC, 2016)

This might not affect the current decision making of late stage customization possibilities directly. However, usage of recycled plastics in packaging materials will probably increase (PackagingDigest, 2015). This means that the new customization step must be prepared for that distinct possibility.

3.1.7 Floor space

The goal is to find a solution that customizes the packaging in line at the last possible stage. This means that the solution must be applied before the packaging is distributed in the production lines. The application of this method requires space to create the information and apply this information to the packaging. These two steps can be combined or separated.

These separate or combined steps take up floor space. This floor space is limited, as seen in chapter 2.1. Implementation of solutions that require a significant amount of room to operate are not options for the current setup of Wolvega.

3.2 Solution space

3.2.1 Time to market

The floor space is limited, but if the new implementation reduces the required storage, floor space is created there for implementing that change. When the generating information and applying information are separated, the information generation step could be located there.

Having the generation of information on the packaging location creates less order times and more flexibility. Having the control over the sequence in which information is produced creates the possibility for prioritizing and therefore flexibility in time to market. This possible faster time to market creates the opportunity for implementing designs that respond to the current situation and are in line with the interests of the market. An example of this could be a temporary design during sports world championships that changes after each match.

3.2.2 Automation

Due to the high amount of automation, knowledge of technical packaging machines already exists at Wolvega. The controlling, monitoring and maintaining of the total process is already highly automated. The possibility for a technical solution is therefore implemented more easily than at a less automated location.

3.2.3 Innovation

Due to FrieslandCampina being a large company with high sales volumes and revenue, slight changes in price can create large effects in revenue. This means that innovation that changes the price just slightly are quicker to be considered for implementation than with a smaller company with less sales.

3.2.4 Price reduction

The required amount of new machines for a late stage customization change is high due to the amount of packaging lines. This creates a higher bargaining power for the company which can reduce the machine price.

3.2.4 Broadened scope

Representing large brands means that the graphical packaging quality has high requirements. However, these brands are determined to stay ahead of smaller brands. This means that implementation of new ways of connecting consumers to their products is what they crave. This higher demand for connecting solutions broadens the scope for implementation possibilities and possible solutions.

3.3 Subdivision of requirements

To create a solid base for the recommended implementation possibilities, a subdivision of the requirements is defined. The previous chapters gave a view on the restrictions and requirements from the companies' vision, the current system and its machines as well as the rules which have to uphold by any implementation.

3.3.1 Original requirements

The new implementation must;

- Add in the creation of value or reduce costs.
- Help in offer trustworthy products.
- Reduce the complexity of the packaging system.
- Be monitored easily.
- Be flexible.
- Be able to produce small orders.
- Maintain or reduce CO_2 emissions.
- Improve product quality.
- Reduce waste.
- Reduce the required storage space.
- Reduce the time to market.
- Reduce changeover times.
- Maintain the line capacity.
- Be able to replace the current print size.
- Represent the brand appearance with an adequate print quality.
- Meet the food and safety legislations.

The goal is to create all of these effects with the customization step, but to create the most desired effect, priorities effects have to be made firstly.

The motive of this research is to create a more uniform packaging line, which is less complex and can be monitored easily which should make it more efficient. FrieslandCampina aims at a customization step which can increase supply chain efficiency and result in cost reduction.

This means that the primary goal is to find possibilities to replace the pre-printed top foils and pre-printed labels with unprinted foils and labels that can be printed in-line or be replaced by another possibility that creates this desired effect.

3.3.2 Categories

The previously stated requirements can be grouped into five categories: Quality, Flexibility, Costs, Supply chain complexity, Other added values.

Since a new implementation has to create added value, Quality is ranked first. The category Quality contains the requirements that make up the current product quality, like print quality, brand appearance and food safety.

Flexibility is the main motive for this research. Therefore it is ranked high in the requirements list. The category Flexibility contains the requirements that influence possibilities for shorter runtimes and line capacity requirements.

Costs are important to the choice of implementation. However, they are ranked lower due to the fact that higher direct costs can give secondary cost reduction or profits. Costs contain the reduced storage space, waste and other requirements that can reduce costs.

Low Supply chain complexity makes a system easy to work with. This can be interpreted from the view of the supply chain managers, but also from a view of packaging development or marketing. Supply chain complexity contains the requirements that influence the complexity for multiple departments of FrieslandCampina.

Other added values is a category with requirements that are harder to measure added wishes or less important requirements. An example of a requirement that is harder to measure is the increase or reduction in CO_2 emissions. This requirement can have negative direct influences, but positive influences if production steps outside the company of FrieslandCampina are taken into account.

3.3.3 Requirements

Quality

- Print single packs with a width described in appendix E.
  or
  Print top foils with a width described in appendix J.
- Print labels with a width described in appendix J.
- Print with an optical quality 300 DPI (observable Dots Per Inch).
- Create a scratch resistant print for transportation and consumer usage circumstances.
- Display the currently used Pantone colours(colour measurement system)
- Should not create migration of food hazardous particles.

Flexibility

- Print on the different substrates described in appendix D.
- Print with higher speeds than the currently possible line speeds shown in appendix J.
- Increase the OEE(Overall Equipment Effectiveness)
- Be profitable in shorter production runs. (% of the current)

Costs

- Reduce the required storage space.(% of the current)
- Reduce the printing costs per pack from the current shown in appendix K.
- Reduce the amount of costs made by casting away obsolete materials as shown in appendix K. (% of the current)

Supply chain complexity

- Reduce the complexity of the packaging system by having less SKU's(Stock Keeping Units) in storage.(% of the current)
- Be monitored easily.

Other added values

- Increase the decoration possibilities
  - Individualisation
  - Colour range
  - Added interaction between consumer and brand
- Reduce the time to market of new graphical packaging designs
- Reduce CO_2 emissions created by the total supply chain.

4- Solutions

4.1 Possible solutions

The requirements demand a method that can generate the quality of the current print on unprinted foil. Although the generation of this print does not have to be performed in the production line, the application of this print does. The search for possible methods started by examining current printing methods and the possibility for them to be implemented. Next to this research, other possibilities that change the design of the graphical packaging as well as the structural packaging were investigated.

The research started by learning the different methods of printing and packaging possibilities by reading lectures, a book and internet articles on this subject. This knowledge was used to search online for the application possibilities of printing methods and other methods. This led to the visit of EMpack where packaging companies specialized on different customization possibilities were asked about their vision on the problem and their possible solutions. This led to a more specified search on the possibilities and trends in digital printing. This research was conducted by searching websites that present news for the packaging industry as well as researching companies that produce digital printers. Trends in packaging gave insight in possibilities for this type of printing as well as other application possibilities.

During the period of research the printing trade fair Drupa was held, which generates a platform for the whole printing industry to display their innovations and new products. Since Drupa only takes place once every four years, it is one of the best possibilities to get in touch with innovative companies that create future printing possibilities. These companies usually present their newest innovations and breakthroughs at Drupa.

The findings of this research are explained in this chapter.

4.1.1 In-line printing

The first possibility of printing the packaging is printing directly on the packaging in-line. This in-line printing can be implemented before the packaging is sealed by printing the foils between the unwinding of the reels and the sealing and cutting of the packaging.

In-line printing can also be implemented by printing directly on the top foil after the packaging have been sealed and cut. This however means that the printing will take place on the outside layer of a direct contact material. The effects of the printing process therefore increase. The applying of the print could affect the barriers of the packaging more than when it is applied to the foil before it becomes a part of the packaging. The used materials do have barriers to prevent this migration, but the printing process could weaken these barriers, depending on the process.

Pre-printed foils have a laminated layer applied to the multi-layer foil after it has been printed. This is called a sandwich print. This laminated layer protects the print and reduces the possible scratching and erasing of the print. Sandwich printing is not possible for in-line printing.

Both of the stated types of in-line printing could also apply the printing of labels or cartons. This however affects the integrity of the barriers less since these materials could not be in direct contact with the cheese.

A representation of in-line printing is shown in image 18.

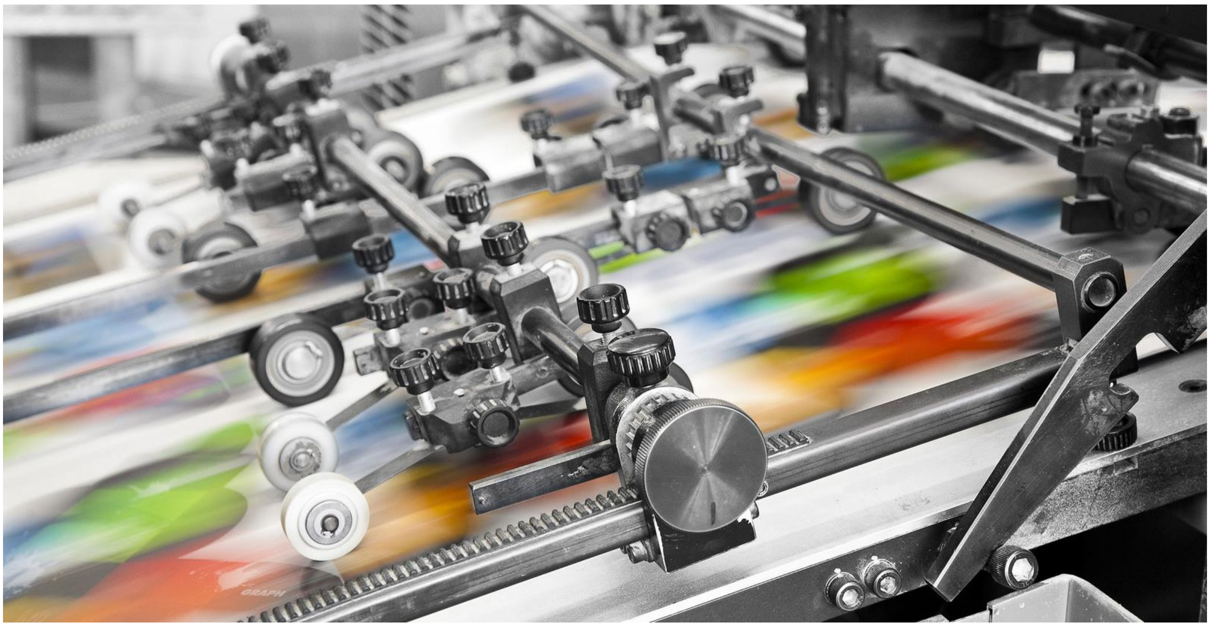

Image 18: In-line printing.

4.1.2 In-house printing

Another possibility uses the current process, with printed foil reels feeded to the sealing machine to create the packaging. However, the change in this solution type is that the currently ordered foils and labels will be printed on the location of the packaging plant. This way waiting times are reduced and more flexibility created. These printed foils and labels can be rolled on reels to be used as in the current situation or directly feeded from the machine to the packaging lines.

A possible location for this in-house printing could be the warehouse, since the warehouse contains preprinted foils and labels which will be preplaced by this method.

In house printing does not give a solution to the changeover times or other OEE related issues. These issues could be addressed by adapting the machine that unwinds the foil reels and guides them to the sealing machine. The current machine supplier does not have a machine with this possibility, but other suppliers could have this possibility. These suppliers are not investigated within this research.

4.1.3 Changed appearance

Changing the current process from preprinted foils and labels to a process where these same foils and labels are bought unprinted and are printed on demand by the previously stated methods can be thought of as straightforward. Less obvious methods that require a larger change for FrieslandCampina are discussed in this chapter.

The proposed solutions are Banding, Carton sleeving and QR code printing.

Banding:

Banding uses a narrow reel of printed foil, which is wrapped around a pack and glued together. The bonding of the foil is achieved by heating two PP layers together. This creates a band wrapped around the pack. An example of a banding machine can be seen in image 19. The machines that apply bands wrap the narrow foil perpendicular to the direction of the conveyor belts of the packaging lines. This requires the pack to come to a complete standstill for a moment to apply the band. To prevent this from happening, a construction has to be made where the packs are transported from the main conveyor belt to multiple banding machines, which customize the pack. Afterwards the packs should be transported back to the main conveyor belt.

A process which requires a complete standstill of a pack creates a delay in the process. The speed in which a banding machine operates does not have to be restricting. With the use of multiple machines per packaging line the only consequence of the complete standstill is a slight delay. However, the amount of banding machines required per packaging line is high due to the fact that this method customizes one pack at a time.

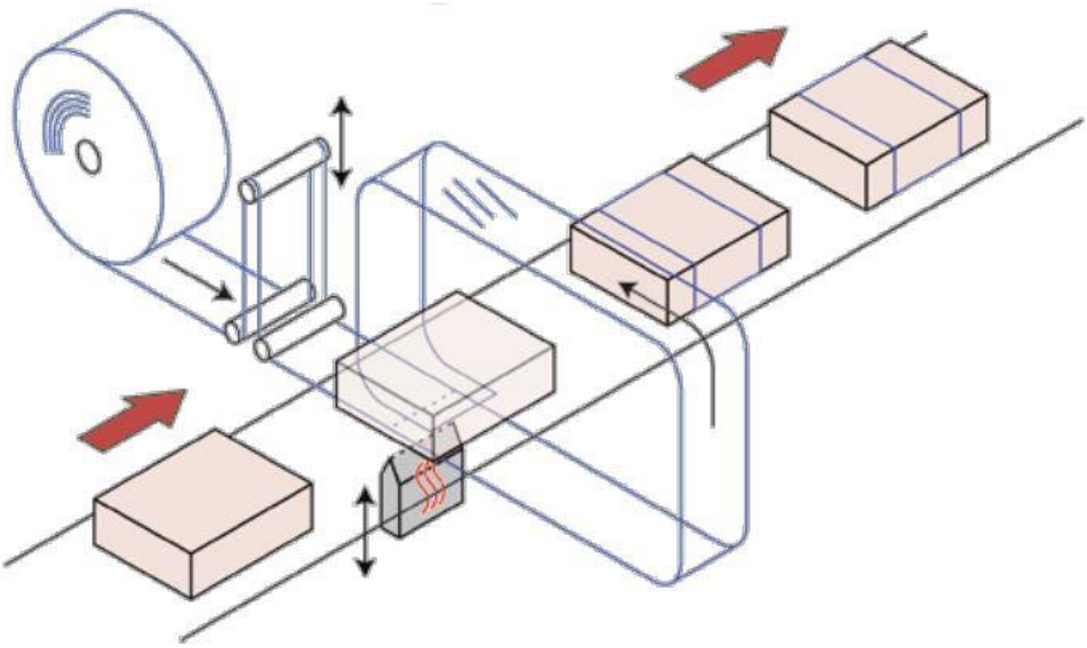

Image 18: banding technology.

This method uses pre-printed foils which are wrapped around the sealed packs. This means that additional material is required for each pack, which makes it more expensive and less eco-friendly.

Using pre-printed foils also means that the time to market is still dependent on the supplier, which probably will not change much from the current time to market. Using banding relies on the current production of packs, which means that the changeover times of the current process still apply. These will not decrease, but do not have to increase due to the banding process. The changeover of the banding foils should not affect the line speed with the use of sufficient banding machines. This way a machine can have a changeover while the process still continues with 1 banding machine less.

The amount of storage could decrease due to the smaller size of the banding foils and the use of unprinted top foils for the primary pack.

For using this technique to create practical packs, an implementation of additional glue and a tearing lines should be added. These are required to maintain the appearance of the graphical packaging after the consumer opens it for the first time.

In addition to these tearing lines and glue, the most common way a band is used is lengthwise to the pack. This requires the conveyor belts to turn each pack 90 degrees.

Carton sleeving:

Carton sleeving also adds material to the pack, and uses a similar method to banding. This method is however much slower due to need of forming the carton around the pack, which requires the carton to fold in a specific shape instead of tightening around the pack. This method also uses more material and can use folding sides to completely surround the pack. This addition of material enlarges the costs even more than banding since this method uses nearly double the amount of packaging material. The reclosability of the pack also is a difficult problem to solve with this method since the consumer is inclined to fully remove the carton sleeve.

QR:

Printing QR codes on the foils of the primary packs can be an addition to the current print or replace the changing information per brand. This could create a demand for less SKU's and be printed in-line or in-house. This technique requires the cooperation of customers to interact with the packaging with the use of smartphones or other QR code reading devices. The implementation of fully replacing the printed information with the use of a QR code can generate the potion for a larger image size on the pack, but does not show information without use of the internet.

Using it as an addition to the current print can create possibilities for showing the origin of the cheese, like the production location of the cheese or the location and type of cows that created the milk used in the cheese. This also created the possibility for linking multiple cooking recipes to the cheese or make interaction possible with the use of augmented reality.

4.2 Printing techniques

There are a lot of different printing techniques. This chapter addresses the four main techniques applicable for printing on flexible foils. Other printing techniques like, letterpress printing, pad printing, intaglio printing, screen printing, lithography, thermal printing and dot matrix printing are not mentioned because they are either not applicable for foil printing, do not produce multiple colours or are not available for industrial use.

Flexographic, offset and gravure printing are traditional printing methods that use engraved printing plates or engraved cylinders.

For these traditional printing methods, switching to another printing image requires a replacement of printing plates. After changing the plates, the system has to be tested for print quality by printing and checking a small batch. This testing can take 3 to 15 minutes, depending on the complexity of the job and the automation level of the press. Changing a colour on a cylinder requires a complete cleaning of the system which takes up a long time.

Traditional printing methods print one colour per cylinder. The standard colours that are represented are CMYK(Cyan, Magenta, Yellow and Key). Key represents black ink. Additional colours are added to the machines to create a larger colour gamut. A representation of the regular CMYK gamut is shown in image 19. Also lacquers can be added with the use of cylinders. This results in printing machines with up to 13 colours.

The quality of these traditional ways of printing is hard to quantify because of the analog processes. They do however differ in quality which will be explained further on.

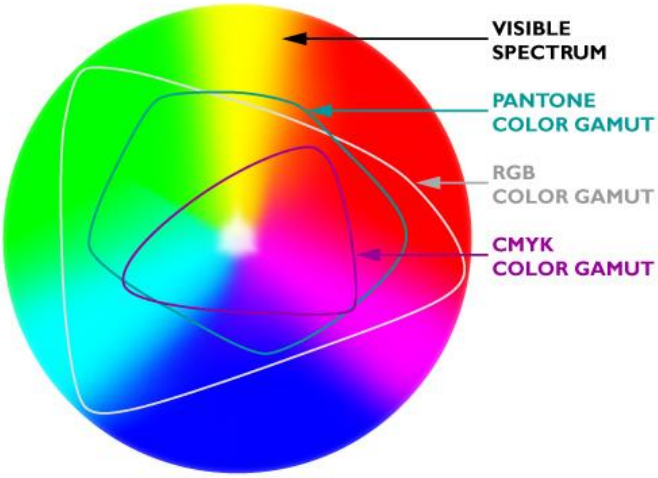

Image 19: Colour gamut.

4.2.1 Flexographic

The flexographic printing process is seen as the simplest printing process. The process can be used to print on paper as well as plastics, metals, cellophane and other materials. Flexographic printing is mainly used for packaging and labels and to a lesser extent also for newspapers.

How (High Definition) flexographic printing works

In flexography the content that needs to be printed is on a relief of a printing plate, which is made from rubber. The idea behind flexography is similar to a letterpress. Where the letterpress uses a stamp, flexography uses a rubber plate, etched with tiny grooves that pick up ink. Each colour station contains a tray of ink which goes through a series of cylinders before it is applied to the substrate. Image 20 shows the flexographic printing method.

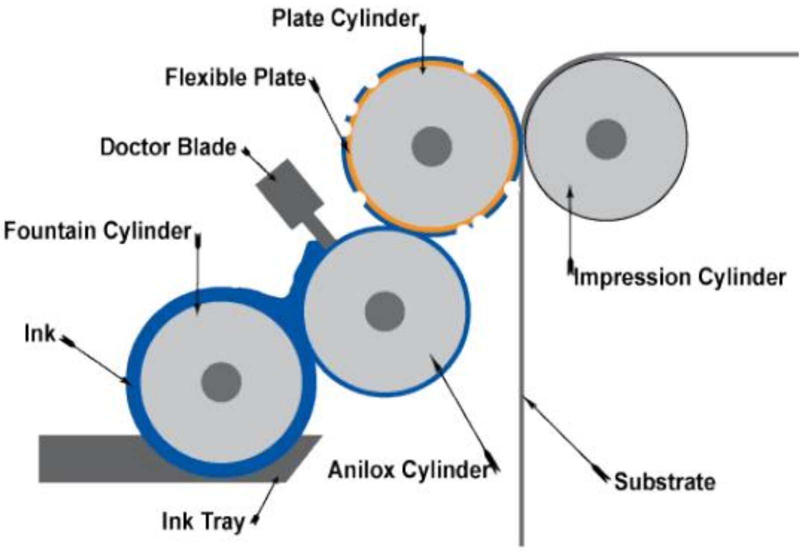

Image 20: Flexographic printing.

A printing unit consists of the following components:

The inking system

The ink used in a flexographic printer is a low viscosity type of water based ink. This ink is stored in a reservoir, which feeds it to the printing plate or cylinder. There the ink is transferred to the substrate. The amount of ink is controlled by the anilox cylinder, with a doctor blade removing the left over ink. The anilox cylinder contains engraved cells which transport the ink.

The plate, impression cylinders and metering system

The rubber stamp (plate) wrapped around a cylinder which rotates and picks up ink from a reservoir then presses it into the printing material.

The plate cylinder is a large roll to which the printing plate is attached. The plate is usually made from a soft flexible photopolymer. The plate uses a raised surface to transfer the ink. This raised surface prints the image directly to the substrate with the use of a pressurized impression cylinder (Prepressure, 2016) (Ten Klooster R. , 2013) (Highnell Book printing, 2016).

4.2.2 Offset

Offset printing is the dominant industrial printing technique – used for printing a wide range of products such as cards, stationery, leaflets, brochures, magazines, books or packaging.

How offset printing works

The full name of the offset printing process is offset lithography. Both terms each describe part of the process:

- Lithography is a printing process in which the image area and the non-image area co-exist on the same plane. That means the surface from which you print is completely flat. This is feasible because of a very useful chemical principle: ink is an oily substance, which means it repels water. If you can create a surface on which some parts contain a thin layer of water, those areas will repel ink. The image areas need be lipophilic (ink recipient), while the non-printing areas need to be hydrophilic (ink repellent)

- Offset refers to the fact that the image is not transferred from a lithographic printing plate to the substrate. Instead the inked image is transferred from the printing surface to a rubber blanket and then to the substrate. This process requires a flat surface.

Image 21 shows the offset printing method.

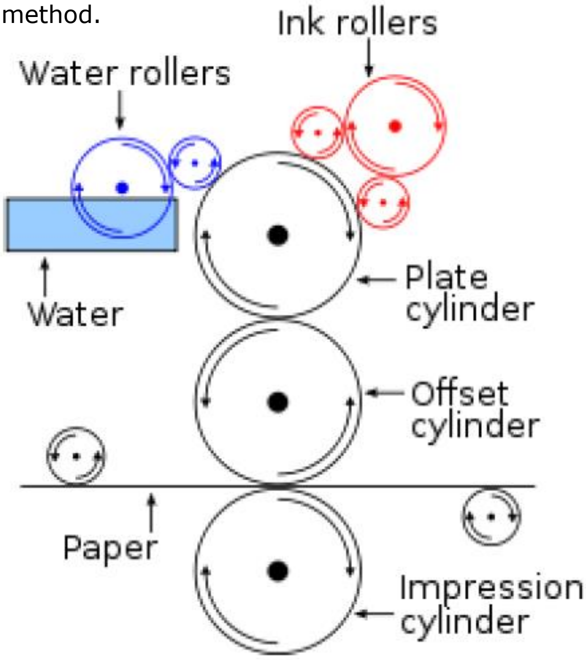

Image 21: Offset printing.

A printing unit consists of the following components:

The inking system
The ink used in an offset printer is offset ink, which is a very viscous type of oil based ink. This ink is stored in a reservoir, which feeds it to the printing plate or cylinder. There that ink is transferred to the substrate. The inking system needs to break the thick, viscous ink down into a thinner uniform ink film. This is done using a set of rollers. The amount of ink used is controlled by a controller key that manages the gap between the reservoir and the first roller. Controlling that gap is done manually with a screw on some presses but nowadays those keys are often motorized. The keys are lined up in a series across the width of the ink fountain so that more ink can be transferred to the part of the substrate with a higher colour density. The inking system assures that a thin layer of ink that is typically 0.2 to 0.4 mils thick is transferred to the printing plate.

The dampening system
The dampening system makes sure the non-image areas of the printing plate are moistened so that they will repel ink. This is mainly done using water, but additives are needed for long print runs to improve the ink repellency, lower the surface tension, desensitize the non-image plate regions and make sure corrosion mildew growth does not cause issues. To make sure an even layer of water is put down on the non-printing parts of the printing plate, a mechanism similar to the inking system is used. The dampening system is, however, less complicated and requires fewer rollers.

The plate, blanket and impression cylinders
The plate cylinder is a large roll to which the printing plate is attached. The plate is usually made from aluminium or polyester. The image areas are burned into this plate. Its non-imaging parts

will be covered by a thin layer of water that is applied by the dampening system. This means the ink which is fed by the inking system will only adhese on all the other areas. During printing this image created by ink is transferred to a rubber blanket that is attached to the blanket cylinder. From there is the image is transferred to the substrate. An impression cylinder carries the substrate through the printing unit and provides a hard backing against which the blanket can impress the image on the substrate. Not all presses use impression cylinders. There are for example perfecting presses that print blanket-to-blanket: the impression cylinder is replaced by a second blanket cylinder, printing both sides of the press sheet simultaneously in a single printing unit (Prepressure, 2016) (Ten Klooster R. , 2013) (Highnell Book printing, 2016).

4.2.3 Gravure

Gravure is also known as rotogravure, is used for high volume work such as newspapers, magazines, and packaging. Gravure is gradually losing market share to offset for publication printing and to flexographic for packaging applications.

How gravure printing works

Gravure uses a technique which does not use printing plates but engraves an directly into a printing cylinder. This is a metal printing cylinder which is chrome plated. This allows it to last much longer and can be used for more impressions before it wears out.

The gravure printing process is shown in image 22.

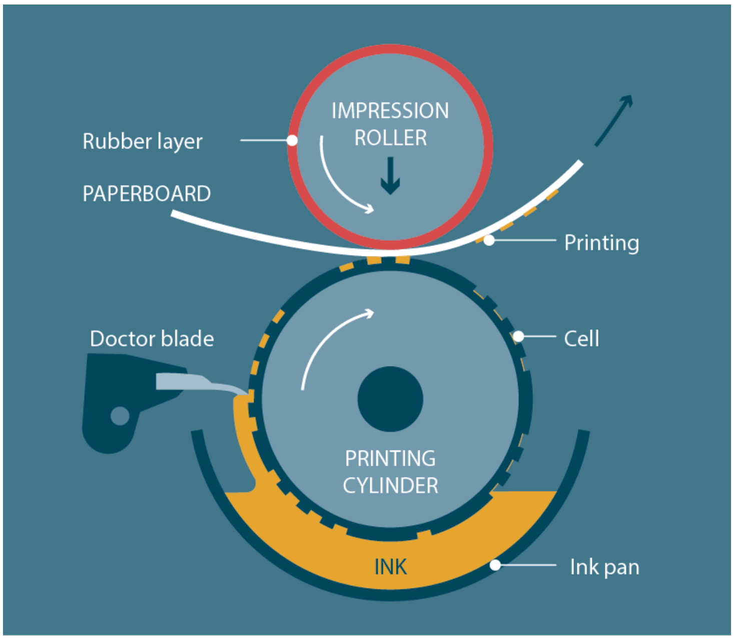

Image 22: Rotogravure printing.

A gravure press consist of the following components:

The inking system

The engraved cylinder is immersed in a bath of thin solvent-based ink. The dots in the cylinder pick up the ink when they pass the bath of ink. The additional ink taken by non-image parts is cleaned off by the doctor blade. This leaves only the engraved dots with ink.

The engraved cylinder and impression cylinder

The engraved cylinder is engraved with dots of the image. The depth of the individual dots creates a difference in tonal value. Deep dots enhance a lot of ink and will create dark areas, while shallow dots are translates in lighter areas. The substrate is pressed against the surface of the engraved cylinder by rubber impression rollers to transfer the ink to the substrate. This method also uses an electrostatic charge to ensure the transfer of all ink from the cells to the substrate (Ten Klooster R. , 2013) (Highnell Book printing, 2016).

4.2.4 Digital

Digital printing is not a traditional printing method and operates in a completely different way from the previously stated methods. The information input for this method is digital, which creates the possibility for controlling each part of the printing process at any given moment. Changing an image only requires a digital input and therefore creates flexibility (Hultén, 2009). Digital printing is increasingly utilized for print jobs that were previously printing using offset, flexographic or gravure printing.

There are different printing methods which operate with the use of different technologies. Some of these printing methods can use multiple technologies to produce the image. These methods have certain effects which can be controlled by the quality of the machine, which are also influenced by the ink types available for digital printing.

All of these distinctions will be addressed in this chapter.

Printing methods:

Inkjet printing

In an inkjet printer the image that needs to be printed is created by small droplets of ink that are propelled from the nozzles of one or more print heads. The individual droplets created by an inkjet printer are so small in size that they create the illusion of the image. Inkjet devices can print on a wide range of substrates such as plastics but even wood or stone. It is also economical for short run productions.

Printing direction

There are two ways a print head can create an image, by scan printing and by single pass printing. These methods are shown in image 23. Scan printing is a method where the print heads are reciprocated across the substrate while the substrate is transported intermittently. All home-use inkjet printers and most large-format printers use this printing method.

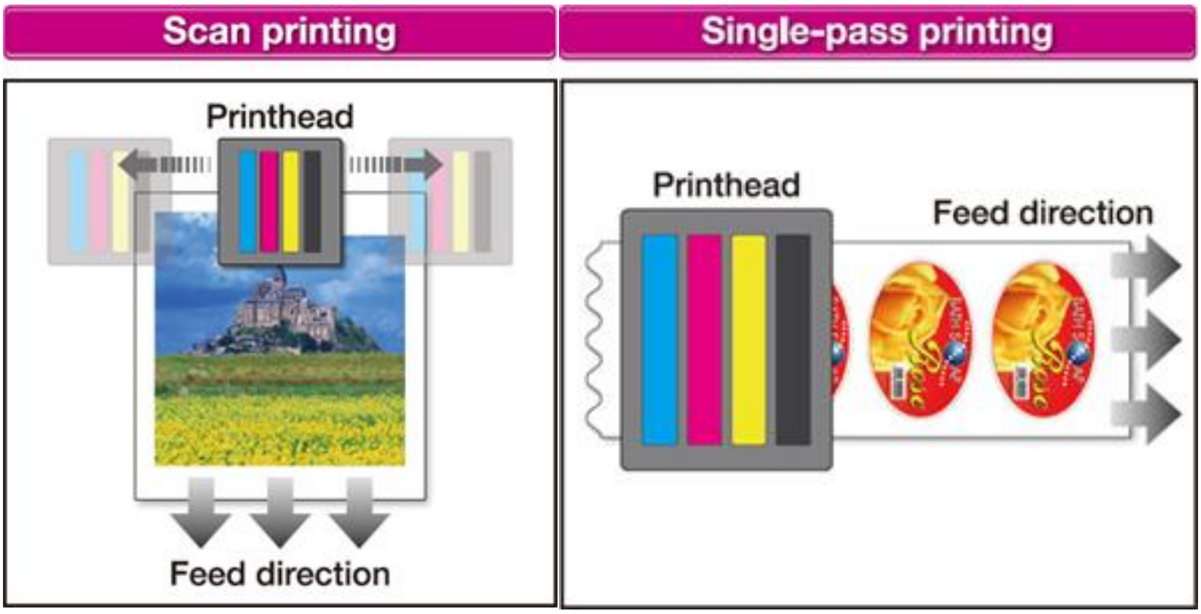

Image 23: Inkjet print directions.

Single pass printing is a newer method where the print head is required to be as wide as the required print on the substrate. Industrial inkjet applications have been adopting this method because of its high productivity.

There is a third way of printing digitally with inkjet. For now only one company has that technology put to use, which is HP. HP prints digitally using inkjet as well as offset technology. The print heads print in a single pass direction, but not directly on the substrate. The print heads print on an intermediate cylinder with a rubbery blanket. This creates a uniform layer of ink that is then applied to the substrate. This creates a high image solution because the ink gets absorbed less by the substrate. The rubbery blanket also works as a shock absorber and pressure pad ensuring a good ink transfer to the substrate.

Print heads

There are currently two main print head types, Piezo and Thermal, which are shown in image 24.

The piezo print head applies electrical signals to ink chambers made of piezoelectric crystals, causing deformation of the chamber walls and roof to eject ink through tiny nozzle holes.
The jetting principle mechanism and the chemical properties of the material make it possible to use various types of ink including chemically reactive solvents and UV curable inks(inks will be explained in further on).

The thermal print head heats ink in the chamber to generate vapour bubbles that eject ink drops from the nozzle. The head is made by a photo-litho process, enabling cost-effective production of many nozzles at a higher resolution than possible with piezo heads.

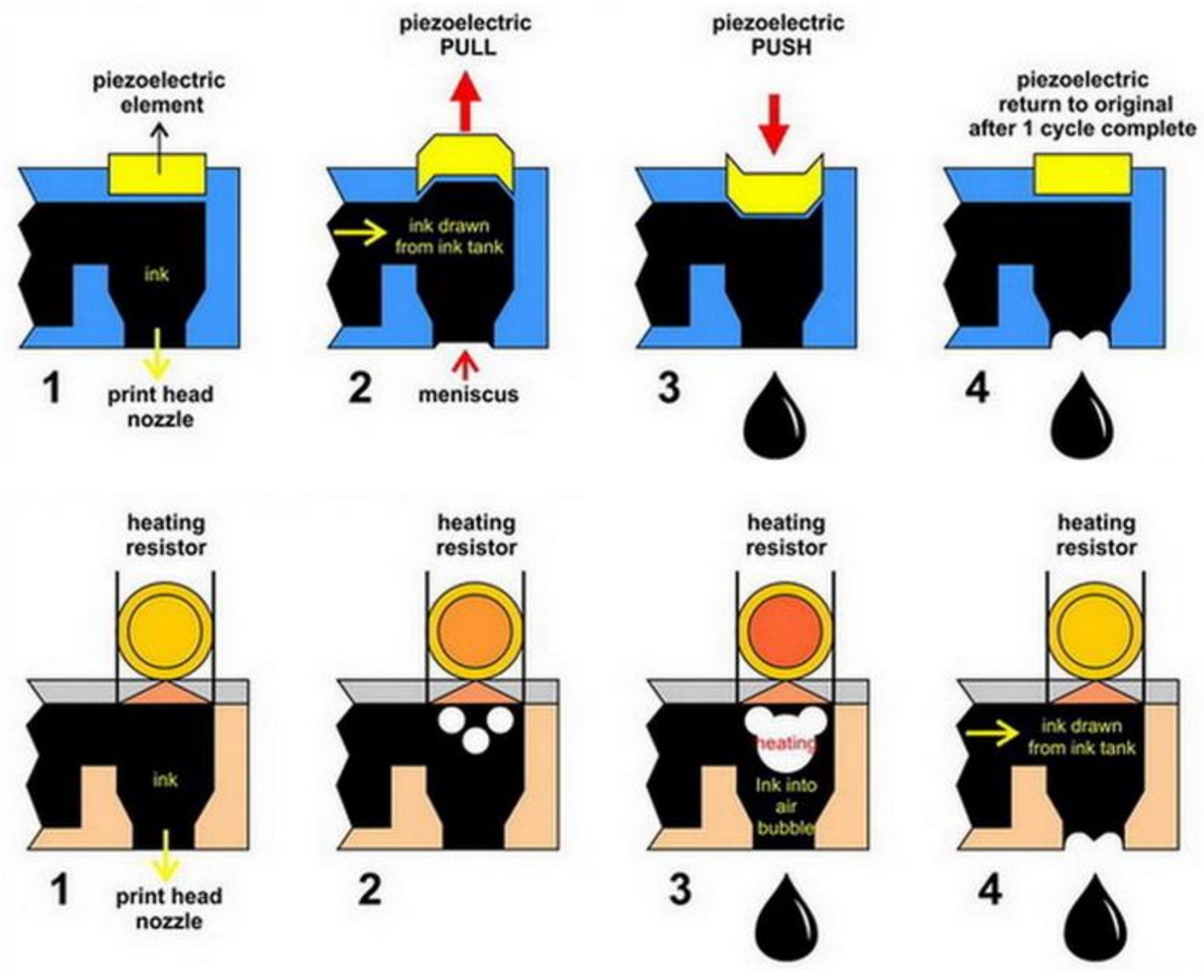

Image 24: Piezo and thermal print heads.

Effects

There are a couple of effects that affect the image quality of inkjet printing, which are meniscus, satellite drop, colour bleed and bronzing.

Meniscus: Vibrations can cause a change in drop velocity an directional quality of a droplet that is jetted from a nozzle. This can cause a change in the shape of the ink surface, which is called meniscus. This change in meniscus can create a deviating shape when the ink droplet hits the substrate, causing disturbance of the image.

Satellite Drop: Small droplets or droplets that are separated from the main droplet are called satellite drops. These droplets are affected more by environmental influences, this can cause a reduced directional quality and droplet timing. An example of satellite drop forming can be seen in image 25.

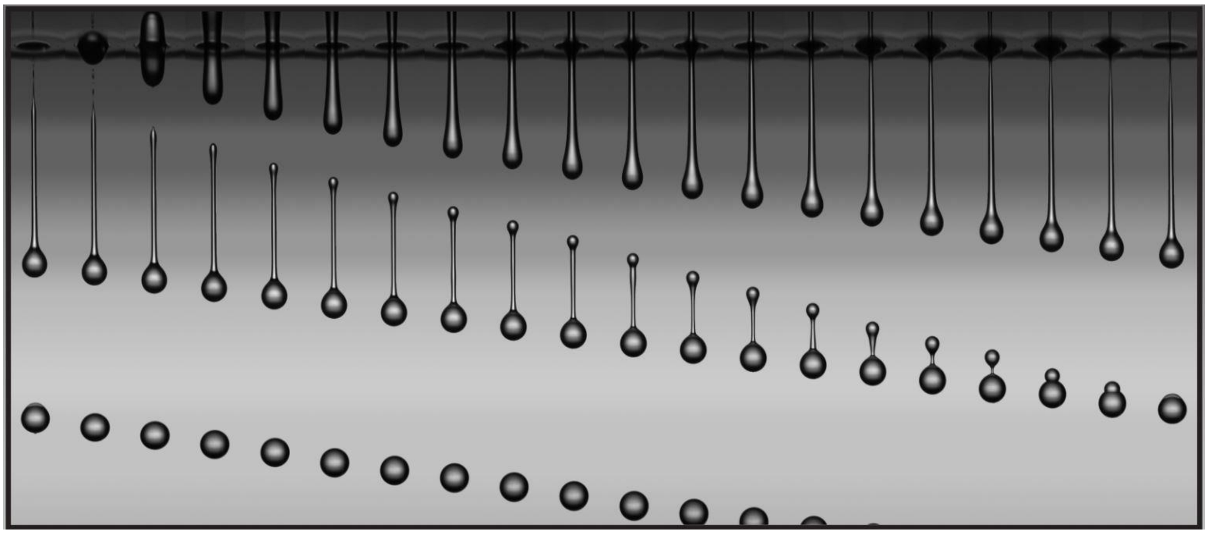

Image 25: Satellite drop formation.

Colour Bleed: Colour bleeding is the effect when two colour droplets touch each other and submerge into eachother. This can be caused by usage of too much ink or unwanted substrate absorbtion. Colour bleed is shown in image 26.

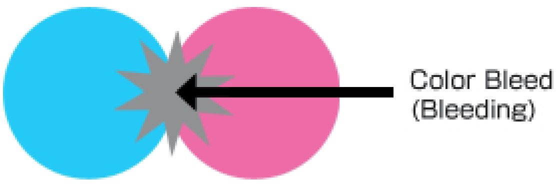

Image 26: Colour bleed.

Bronzing: Bronzing is a visual effect which shows a grey tone which tends to have a bronze or metallic reflection when viewed at a certain angle. This effect can show when C, M and Y inks are bleeded (Konica Minolta, 2016).

Laser printing

Laser printing uses xerography to create the printed image. It uses a photo conducting metal cylinder(which is called a drum) to transfer the image to the substrate. Initially, the drum is given a total positive charge by the charge corona wire, a wire with an electrical current running through it. (Some printers use a charged roller instead of a corona wire) As the drum revolves, the printer shines a laser beam across the surface to discharge certain points and create an electrostatic image. After this electrostatic image is created, the printer coats the drum with positively charged toner. Since it has a positive charge, the toner particles are attracted to the negative discharged areas of the drum, but not to the positively charged areas. With the toner pattern affixed, the drum rolls over the substrate, which is moving along a belt below. Before the substrate rolls under the drum, it is given a negative charge by the transfer corona wire (charged roller). This charge is stronger than the negative charge of the electrostatic image, so the paper can pull the toner powder away. Afterwards, the substrate is guided through a fuser which melts the toner to the substrate. This process creates one colour at a time. The amount of colours that can be printed is therefore determined by the amount of cylinders used. An overview of this process is shown in image 27 (Highnell Book printing, 2016) (Harris, 2016).

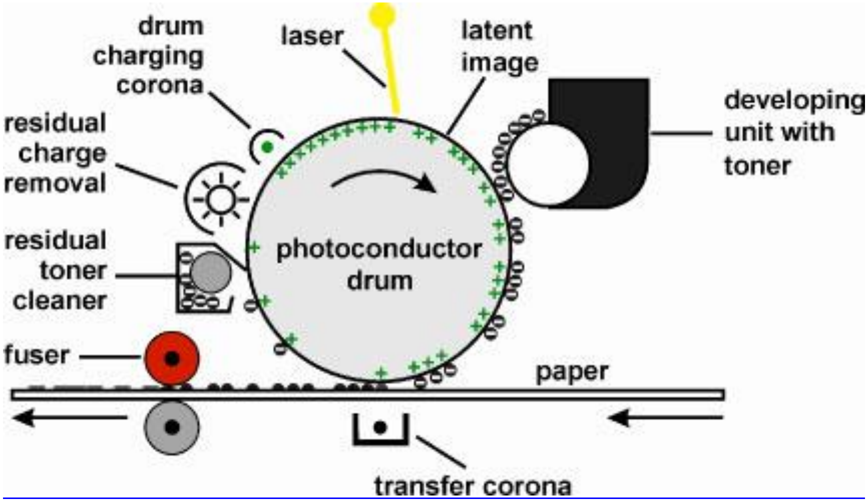

Image 27: Laser printing.

Ink types

There are a lot of different compositions in ink, with particles that differ in migration levels and in hazardousness. There are inks made for coding boxes and inks that are eatable and are printed directly on food. This makes it hard to analyse every type of ink. Therefore, the focus in inks for this report is on popular ink types for digital printing.

The inks used in inkjet printers consist of dyes mixed with a highly fluid vehicle or carrier that form very small droplets, can pick up an electrical charge, and can be deflected properly to fall in the right place for the formation of a printed character or image.

Xerographic inks are commonly referred to as toner and consist of a fine, dry powder coated with the desired colour imparted by a coloured resin binder. The important consideration is not only particle size, but also electrical properties (PrintWiki, 2016).

Xerographic inks are dry which decreases the amount of migration that occurs when the ink hits the substrate. The inkjet inks however are highly fluid and tend to migrate more. This is why UV inks were invented. These could be dried with the use of a UV curing light. This technique is used in printing digital as well as printing with traditional methods.

The particles in UV inkjet inks however needed to adapt their properties to create a faster curing. This meant that most UV inks were not safe to use for food packaging.

This created the demand for low migration UV inks. Low migration inks refer to ink formulated with the use of raw materials that have been recognized as ones that could pass through a substrate. Yet because there are so many different combinations of inks, printing processes, and end uses that testing is needed to be sure that the correct ink is used. This depends on the curing speed, the proximity of the ink to the substrate during ink-jetting, material properties and much more (Schelfaut, 2013).

The innovations of UV curing led to the use of LED light to speed up the process and make the process easier to control. Specialized LED UV inks were developed for this application (Francer, 2014).

In May of 2016, a company called Siegwerk has invented a low migration UV LED ink that can be used for food packaging. This means that the LED UV curing printing machines can be possible solutions for late stage customization, due to their short curing period and low migration (Drupa, 2016).

There has also been an innovation in research for nanographic pigment particles. The company called Landa created these particles which have different characteristics than regular ink particles. These nanographic pigment particles reflect more light, giving them a higher colour gamut. The company announced their newest machines at the Drupa of 2016, which create digital prints that are cost effective for longer runs than regular digital printers due to the smaller droplets required for printing the same surface. Examples of nanographic printed droplets by Landa are shown in image 28.

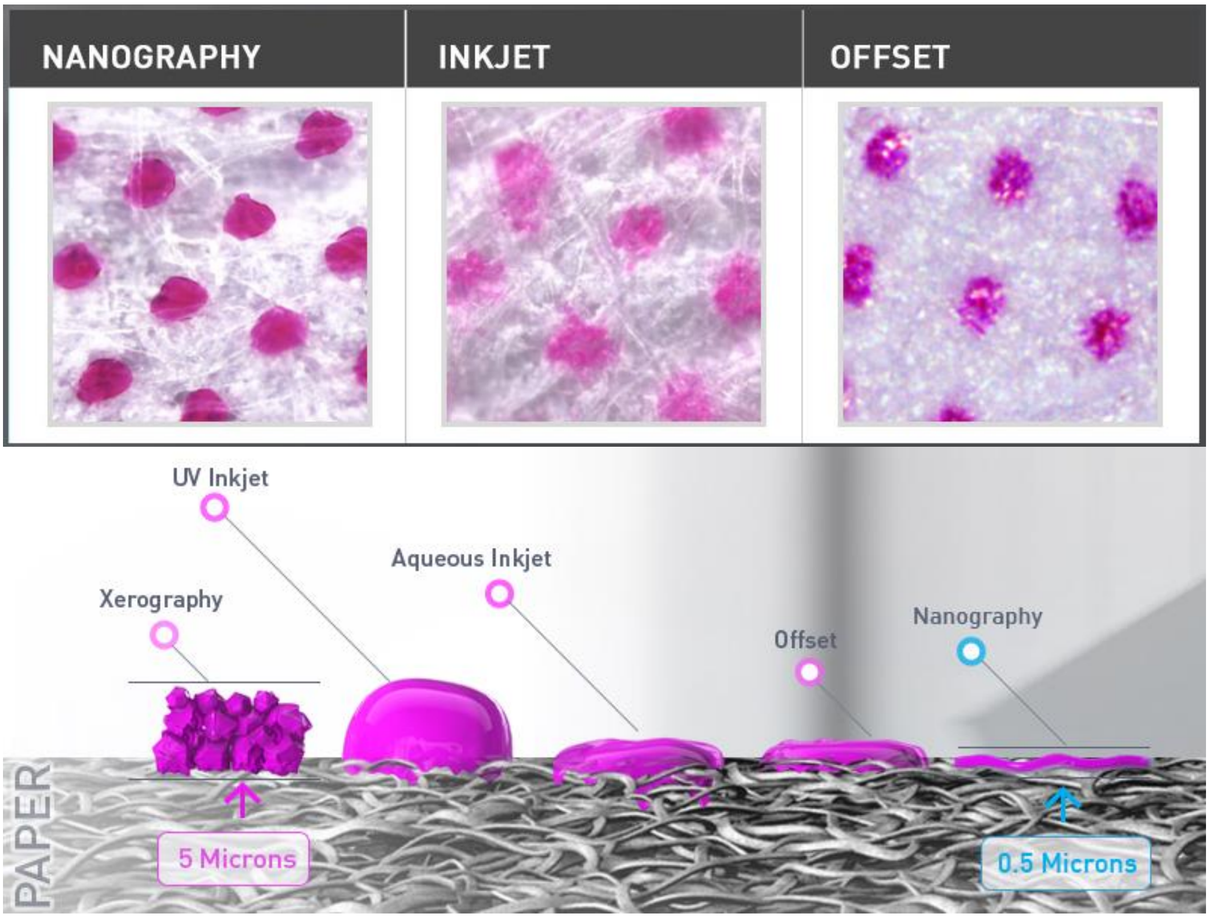

Image 28: Nanographic droplet size.

4.3 Changed appearance possibilities

This chapter shows the possibilities for the options than require a change in graphic packaging design. Carton sleeving is not mentioned in this chapter due to the fact that it is a slow and expensive process which brings more complexity.

4.3.1 Banderoll

Banderoll is somewhat similar to the carton sleeving process, but is less complex to adapt to the current packaging. It will require a tearing strip in the band as well as a slue layer to keep it in place after the packaging has been opened.

Banderoll does require the packaging to rotate 90 degrees to create the desired effect. This in combination with the requirement for a complete stop of the conveyor belt makes it hard to implement in the packaging lines. The amount of redundant machines required to reduce changeover times requires a lot of floor space as well as render half of the machines useless for most of the time. The process also does not create more flexibility since it requires pre-printed foils. This method does however reduce the requires storage space although adds SKU's.

4.3.2 QR code

The QR code solution in the case of replacing the current print does not give a good solution for all the current customers. A lot of customers choose their product in a split second and are not looking at their smartphone while doing so.

The solution which adds a QR code to the current packaging can offer some results to the need for information on recipes, information on the origin of the cheese and promotional bonding with the brand. The QR code needs to be printed in line to create the most flexible solution for this added value.

Since this method requires another technology to generate the print, it can be seen as an addition rather than a possible solution.

4.4 Foil, labels and boxes

The print requirements of primary, secondary and tertiary packaging differ. Primary packaging is the representation for the brand in most shelves. This means that the printing requirements for the foils and labels used for primary packaging are high as well. Both foils and labels require high quality print, but labels sometimes require an additional print on the back for promotional purposes. These labels are varying in shape and size as well making it harder to replace with a single late stage customization solution. These requirements can be seen in appendix K. The requirements are high as well for some of the boxes used for secondary packaging. The majority of these boxes however require less printed colours since they are only used for transportation. The label requirements for these boxes are low and the variation in size as well. The requirements for tertiary packaging are only the printed pallet labels which are uniform in size and low in requirements. The required print size for foils, labels and boxes can be seen in appendices J,G and K.

The print quality can be solved with the use of one of the previously stated printing techniques, but adapting the shape of a print, as requested for some labels, requires a die cutter.

Die cutting is a process where printed substrates like labels get cut into irregular shapes. This is done by a revolving cylinder that contains a knife in the requested shape, that is rolled over the substrate. This method can only create one shape and has to be replaced for each other shape required.

Other possible die cutting techniques might be available, but are not researched within the scope of this research.

4.5 Suitable technique

The previously stated techniques each have advantages in one way or the other. The main goal of this is however to find a customization method applicable for the cheese packaging process. This requires the technique to mainly be flexible to reduce changeover times and improve OEE of the process.

The methods are tested tot the requirements of chapter 3.3, which gives an insight in the suitability of the techniques.

To give an additional view on the trends in the packaging world that need to be taken into account research was done on the customer wishes regarding packaging design. This way it could be determined which of the packaging types would probably increase in demand. The tested packaging type within the scope of this research was Freshlock 2.0. This packaging type will replace the pre-formed trays and the previous version of Freshlock by the end of the year. This replacement will enlarge its part of the production to be taken into account in terms of print width and speed for late stage customization possibilities. The test and the results can be seen in appendix I.

4.5.1 Decision model

The decision model shown below tests the techniques to the requirements. The changed appearance possibilities are not addressed since they are either an implementation which demands a change in appearance, an increase of SKU’s, more complexity and high floor space requirements or reliable on technology that is not used by everyone.

	Flexo	Offset	Gravure	Digital
Quality				
Print width foils	+	+	+	-
Print width labels	-	-	-	+
Print quality	+	+	+	+
Scratch resistance*	N/A	N/A	N/A	N/A
Colour gamut	+	+	+	+
Low hazardous migration	+	+	+	+
Flexibility				
Printable substrates	+	+	+	+
Print speed	+	+	++	+
Changeover time	-	-	-	++
Costs				
Required storage space	-	-	-	+
Implementation costs	-	--	--	+
Printing costs short runs	-	-	--	++
Printing costs long runs	+	+	+	--
Amount of obsolete materials	-	-	-	+
Supply chain complexity				
SKU's in storage	-	-	--	+
Monitoring and usage	-	-	-	+
Other added values				
Individualization	-	-	-	+
Consumer brand interaction possibilities	-	-	-	+
The time to market	-	-	-	+
**CO_2 emissions	+/-	+/-	+/-	+
Implementation				

Short term(current possibilities)	-	-	-	+/-
Long term(future possibilities)	-	-	-	+

*Scratch resistance is dependent on the lamination possibility, which is a separate method.
** this depends on a number of things, including the used run times.

Explanation of the shown values is done by researching current machine possibilities and relying on previous packaging decoration research of FrieslandCampina.

Quality:

Print width foils: The current print width of traditional printing machines is larger than digital printing machines and have adequate widths. There are wide web digital printers, but they use a scan printing technique, which makes them too slow to be implemented. There are digital printers which use a single pass printing technique, but are only cost effective for high speed narrow web printing.

Print width labels: Where the traditional printing methods are able and cost effective to print on wide web substrates, they are not cost effective for narrow web printing, like label printing. Digital printers however are cost effective in these runs.

Print quality: The print quality of traditional printing methods is high due to the analog processes. Gravure used to have the highest quality, but HD flexographic printing nowadays can print with the same quality. The same applies for the quality of digital nanographic printing, which can print with offset quality. There is still a difference in quality between the different printing techniques due to ink bleeding and spreading of inks, but all technologies can produce the required print quality.

Scratch resistance: This part of the requirements is not applicable since laminating, which can increase scratch resistance, is a separate method. The inks used for the different techniques also vary in scratch resistance, making it hard to quantify.

Colour gamut: The different techniques can use multiple colours to create the image. Adding an extra colour to the process increases the colour gamut. The required colour gamut can be achieved by each printing process.

Low hazardous migration: Where digital printing inks, especially UV inks, used to be prone to migrate. New innovation on low migration inks however created fast curing LED low migration inks.

Flexibility:

Printable substrates: All techniques can print on paper based, as well as plastic film substrates.

Print speed: All techniques can print faster than the demanded printing speed.

Changeover time: Traditional printing methods require the machine to come to a standstill to change printing plates or cylinders. This requires an extremely high changeover time. The system must also be tested after changeover to insure the print quality. Digital printing methods do not need a machine stop to changeover, nor need an intermediate test run on the substrate.

Costs:

Required storage space: Traditional methods use printing plates or cylinders that are specific for one type of print. These plates an cylinders need to be kept in storage awaiting a changeover. This takes up a lot of storage space for the current amount of different prints. Digital printing however does not require any storage capacity beyond the storage of inks, which other techniques also require.

Implementation costs: Previous research of FrieslandCampina stated that flexo printing has low machine costs, offset printing high machine costs and gravure printing also high machine costs. Digital machine costs were not mentioned in this report but can be low in comparison due to the narrower printing width that can be produced by digital printing.

Printing costs short runs: Each new design for traditional printing methods requires new printing plates or entirely new cylinders. The costs of these new plates and cylinder make the traditional methods costly in short production runs. Digital printing does not require a change of material and is very cost efficient in short production runs.

Printing costs long runs: The effect of the costs of print plates is less when the length of a production run increases. Ink costs are increasingly important. The ink costs of digital printing methods are high in comparison to the printing inks of traditional methods. This results in low printing costs for long runs on traditional methods and high costs for digital printing.

Amount of obsolete materials: Due to the use of printing plates and cylinders, traditional printing methods have more obsolete materials due to a change in design.

Supply chain complexity:

SKU's in storage: Due to the use of printing plates and cylinders, traditional printing methods have more SKU's in storage. Since gravure uses a whole new cylinder for each print, it has the lowest score.

Monitoring and usage: Changing plates and cylinders is a highly physical activity which is required for each changeover. Digital printing only requires a change in digital input, which can be automated. Monitoring both processes can be automated with optical scanners, which send the information to a monitoring computer.

Other added values:

Individualization: Individualization requires a fast changeover, which is possible for digital printing, but not for traditional methods.

Consumer brand interaction possibilities: Adding information like QR codes can increase the brand interaction of the packaging. This can be printed by each method. However, a changing print that adapts to current interests like promotion of sports events requires new plates an cylinders for traditional methods.

Time to market: The time to market for traditional methods is longer because they are required to wait for a newly printed plate or cylinder. Digital printing can change the appearance instantly.

CO_2 emissions: CO_2 emissions are hard to specify. The currently represented neutral and positive results come from the demand for shorter production runs. The obsolete materials created by traditional methods is relatively more than those of digital printing methods.

Implementation:

Short term: Current possibilities that solve the issues and are able to print at the current speeds and widths of foils are not found within this research. Digital printing of labels does have possibilities because of lower printing width requirements.

Long term: Long term possibilities are hard to predict. However, some companies are innovating digital printing methods like DataLase for digital laser printing and Landa for digital inkjet. The solution of DataLase is expected to be available at the end of 2018. Landa has got running machines that use a technology that is applicable for in-line printing. These machines however are made for high speed runs, are extremely large and have high implementation costs. Machine specifications are discussed in chapter 4.6.

4.5.2 Implementation possibilities

Banding and carton sleeving still require pre-printed materials which each have supplier order times. Reduced changeover times from one print to another is also hard to achieve and will require a redundant amount of machines which will not be used for most of the time.

QR coding as a replacement is not an option at this moment and QR coding as an addition to the currently displayed information still requires a printing technique.

The traditional printing techniques all require a lot of work to changeover from one print to another. They might be cheaper to run for long production runs, but they are not applicable for printing short runs.

Digital printing however creates possibilities for in-line printing as a late stage customization. The speeds of digital printing presses is higher than the required speed. It is cost effective in shorter runs due to no set-up costs, no minimum print quantities and no plate costs. The variable data that can be printed allows for individualisation packaging. Effects can be printed by using different ink types like UV invisible inks that are fluorescent under UV light or using raised ink to create an emboss effect. Possibilities of digital printing are shown in the next chapter.

4.6 Digital printing machines

There are a lot of different digital printing machines varying in speed size quality and curing options. The overview shown in appendix M gives a view on the possibilities that are able to print the required width of foils, the speed or that has capabilities to dry the inks in time to be able to implement them in-line.

5- Evaluation

5.1 Feasability and implementation

This chapter will address the possible short- and long term options as well as draw conclusions and give recommendations. The last part of this chapter will discuss the validity of the research.

5.1.1 Short term options

Since the requirements concerning food safety, print speed, quality and width of foils cannot be met with a solution that fits in the packaging lines, other possible customization possibilities were researched.

The lower migration demands and lack of high care zone requirements of labels applied to boxes and prints on boxes gives possibilities. The requirements for amount of colours used for the printed image on the boxes differs. However if brands agree on a more uniform print quality, a digital printing solution can be implemented in-line.

Secondary labels are currently printed in line. The current quality of this printing is a white label with a black print, varying from box to box. There is no need to replace this process since the demanded quality is met. Full colour labels can be printed in-house which creates the possibility for less storage. This possibility also creates the possibility for higher quality box labels.

Another possible solution is a change in machines for the supplier of the foils. Nanographic digital printing is cost effective in short and medium sized runs, which makes it ideal for cheese packaging. This can lead to lower costs for FrieslandCampina, but does not solve the late stage customization issue. An example of such a printing press can be seen in image 29.

Image 29: Nanographic printing press.

5.1.2 Long term options

Long term options require additional research since technologies might change in the period to the actual long term implementation. One of these possibilities is a CMYK laser printer, which does not add pigments during the printing process. This technology is announced by a company called DataLase, which creates pigments that are printed in see-trough of white inks. These pigments can be activated with the use of a laser. Their current technology only allows for 1 colour to be printed and exposed this way. DataLase did however announce their newest multi-colour solution called “Infinity”. This solution will be able to activate four different colours with lasers using different wavelengths. This can create a full colour image with the use of CMYK pigments.

The advantage of this method is that it can be printed in-between layers and activated in-line. This makes implementation in high care zones possible. The Infinity solution is announced to be available at the end of 2018.

Another option is digital inkjet in-house printing of foils. In-line printing will probably still not be applicable for foils. This is due to the additional lamination to prevent scratching of the image, the costs of these machines and their size. The costs of these machines now varies between 1,5 and 5 million euros, which is not profitable for implementation in 17 packaging lines. The implementation of these machines in-line is also not possible because of their size. However, technologies usually develop to be smaller and more cost effective. This means that implementation in line might be possible in the future. The printing speeds that these machines are designed for are 10 times higher than the required running speeds of the packaging lines. This would make them less cost effective to use in-line. Having one or two machines in-house could be more cost effective.

5.2 Conclusions

In this Bachelors assignment the current cheese packaging process and the surrounding conditions were analysed. The requirements were extracted from this analysis. Possible methods of replacing the current customization in the process were described and tested to the requirements. The most suited possibility was further investigated and possible short- and long term solutions were given. These solutions can be used for further investigation of possibilities in other packaging aspects within the company or as a guide for future research on cheese packaging. Implementation consequences for the possible solutions are in need for added knowledge to make the solution reliable as well as the cutting of some jobs and the creating of others. For now it is not possible for foil to be printed in-line, and other possibilities create a lot of change in the process where further investigation is needed to get a view on the consequences. There are however possibilities for labels and boxes. Labels can be printed in-house which creates the possibility for less storage and with low quality expectations, carton boxes can be printed in-line. To get a more concrete view on any of these changes, strategy plans for implementation and cases need to be consulted with companies that can supply the machines.

5.3 Recommendations

This research describes the possible methods, but not implementation possibilities by companies. Further research is required where business cases are presented to machine suppliers to get a clear view in the costs that need to be made in order to implement a chosen change. Current printers often don’t meet the requirements for implementation because of size and price. Having an adapted version or just a module of a machine, supplied by a company, could however be a possible solution. This also requires further research and consultation with printing companies.

A study on possibilities of an adaption of the current foil reel fed system to reduce changeover times can be helpful. The current way a changeover commences depends on the entire packaging line to come to a standstill, with all its consequences. The possibility of implementing a change on the machine, where the change in foils does not require the whole line to come to a standstill can increase the OEE greatly and requires little change in the ordering system of foils.

Since the production of packaging at Wolvega has high capacities, errors can have extreme effects. Testing and implementing change in packaging done on packaging lines with less capacity creates less risk during the testing and implementation phase.

The company DataLase could create a suitable solution with their CMYK laser printing technique. Since it still needs time to be worked out, the outcome of the technology is still guesswork. The potential however is apparent. Looking into this technique in 2 years could prove useful to the company for many different types of packaging, not solely for cheese.

Since the demand for shorter packaging runs might be solved by a digital solution, further investigation in QR possibilities for brands is advised. Adding recipes for instance takes up a lot of graphical design space when described in the design. However using QR codes can help improve the brand to consumer relations by adding background information, cooking tips and promotional savings.

If FrieslandCampina wants to pursue the possibilities for late stage customization, a multidisciplinary team has to be initiated. This team should work out how an adaption exactly should take place and then work out cases with machine manufacturers. The used inks should also be determined in this process which gives the opportunity to look into smart labelling technologies.

5.4 Discussion

This research mainly focused on basic styles and possibilities due to the lack of expertise in the packaging and printing field. This resulted in a somewhat simplistic research, where some possibilities can be left out of this research. The amount of background information for each step of the research is large, which makes it hard to determine the limit of the research. Research on migration led to low migration inks which led to the chemical structure of these ink types. Not every part of the research is shown in this report.

The figures shown in the appendices are based on e-mail conversations and interviews with employees who each work on parts of the process. Combining this information gives a view on the speeds, widths capacities an quality of the current process. This information might however be interpreted wrongly since answers were often defined in numbers that only partially answer a question.

Differentiating printing machines was hard to do. Each company asked for figures that were not apparent from the research that had been conducted. Case studies to determine prices could not be conducted within this research, which made choosing techniques dependent on general statements made by companies. The specifications stated by these printing manufacturers varies as well. Not only in quantity but in terms used. This meant that specifications had to be made uniform to compare them. This could give a wrong image on the selected machines.

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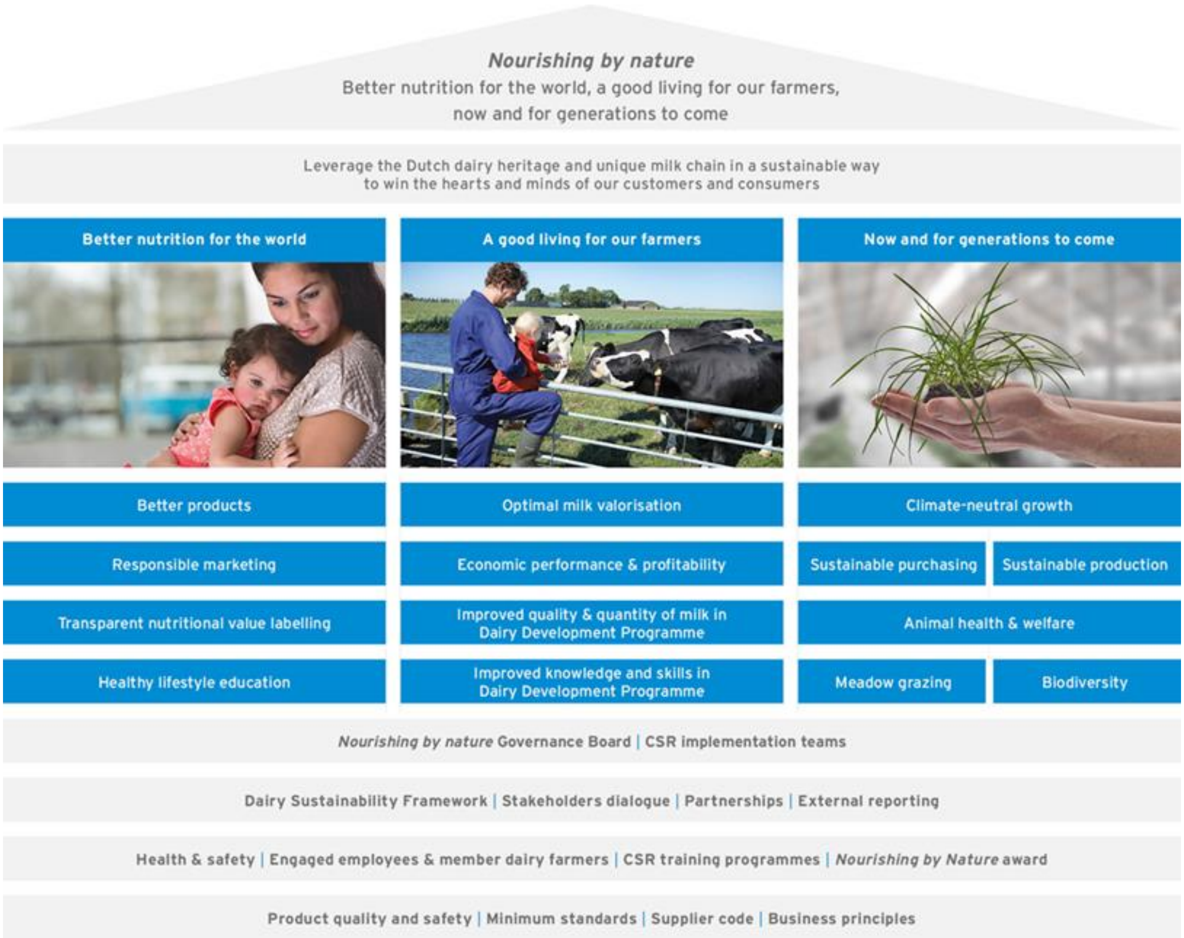
Appendices

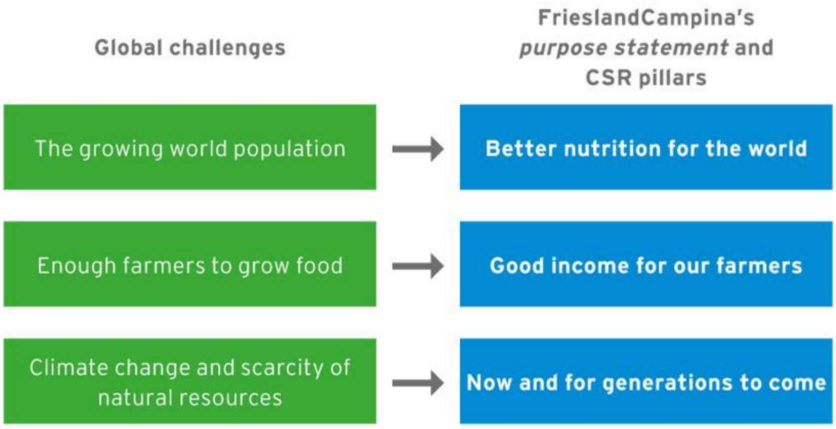
A

CSR strategy house

FrieslandCampina's integrated CSR(Corporate Social Responsibility) strategy consists of various elements that together form the CSR strategy house as seen in the image below.



The three strategic pillars from the CSR strategy house are derived from three global challenges as seen in the image below



The key to corporate social responsibility is the creation of added-value for both FrieslandCampina and the society. This added-value can stem from new ways of thinking, new products, smarter production processes or cooperation with so-called non-government organisations (NGOs) and other stakeholders. The added-value becomes visible in financial value creation through development of new products or the strengthening of a relationship with customers. Social value can also be created by efforts aimed at improving health or combating undernourishment. FrieslandCampina' s CSR policy revolves around this shared value so that not only FrieslandCampina's continuity is safeguarded, but also the health of people, animals, the environment and the future of dairy farming.

B

Research Question

Which late stage customization steps can be implemented in the cheese packaging lines of Wolvega to increase line efficiency, prevent obsolete packaging material and increase production flexibility?

1. What room for implementation is there in the packaging plant Wolvega? (Chapter 2.1)
   1.1. What is the current setup of Wolvega?
   1.2. How much floor space is used for each step of the process?
   1.3. What is the available floor space for a customisation step in the process?

2. What are the current specifications of the primary cheese packages? (Chapter 2.2)
   2.1. What are the different types of primary cheese packages that are made in the packaging lines?
   2.2. What are the area sizes of the package that display information?
      2.2.1. Which parts of the package display information?
      2.2.2. What is the size of these parts?
   2.3. What is the material composition of these packages?

3. How does the current process work?(Chapter 2.3)
   3.1. What are the different steps of the packaging process?
   3.2. What is the current capacity for each of the packaging lines?
      3.2.1. What is their influence on the speed of the process?
   3.3. How are the packaging parts that display information applied to the primary package?

4. What issues does the current process have? (Chapter 2.4)
   4.1. What is the required storage capacity?

4.2. What is the current flexibility of the process?
4.3. How much material is wasted?
4.4. What causes the process to run inefficiently?

5. What are the restrictions for possible customization steps? (Chapter 3.1)
   5.1. What is the current print quality on the primary cheese packages?
      5.1.1. Which printing techniques are currently used to display the information?
      5.1.2. What are the current costs for printing the information?
      5.1.3. What is the print quality demanded by FrieslandCampina?
   5.2. What shelf life effects need to be taken into account?
      5.2.1. What are the migration barriers in the current package materials?
      5.2.2. What food- and safety legislations need to be taken into account?

6. What printing solutions are there for replacing the currently displayed information (Chapter 4.2)
   6.1. What printing techniques are available?
      6.1.1. What is the way of printing?
      6.1.2. What are the costs of these techniques?
      6.1.3. What is the print quality?
      6.1.4. What is the printing speed?
   6.2. Which of these techniques is able to print on the currently used materials?

7. What other methods are there for replacing the currently displayed information?(Chapter 4.3)

8. Which methods are suitable for producing the package information? (Chapter 4.4)
   8.1. What requirements are different for printing information on secondary and tertiary cheese packaging?
   8.2. Which requirements are most important for choosing a technique?
   8.3. To what extend does the printing technique influence the barriers of packages?

9. Which packaging types are expected to gain more popularity?(Chapter 4.5)
   9.1. Which packaging techniques increase in customer demand?
   9.2. Which packaging techniques of Wolvega are similar to these techniques?

10. What possibilities are there for the most suitable customization step? (Chapter 4.6)
    10.1. Trends are there for this customization step?
    10.2. What machines could be used for applying this customization step?

11. Which possible solutions are there in a short term period? (Chapter 5.1)
    11.1. Which late stage customisation steps are suited mostly for FrieslandCampina?
       11.1.1. What are the advantages of these changes?
       11.1.2. What are the disadvantages of these changes?
    11.2. How can FrieslandCampina implement them?
       11.2.1. What process steps need to change?
       11.2.2. What are the consequences of the implementation process?

12. Which possible solutions are there in a long term period? (Chapter 5.1)
    12.1. Which late stage customisation steps are suited mostly for FrieslandCampina?
       12.1.1. What are the advantages of these changes?
       12.1.2. What are the disadvantages of these changes?
    12.2. How can FrieslandCampina implement them?
       12.2.1. What process steps need to change?
       12.2.2. What are the consequences of the implementation process?

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