

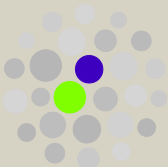
Development of New Easy to Open Cheese Packaging for Elderly in Sweden

A Design Thinking Approach

Santika K. Chenderasa

DIVISION OF PACKAGING LOGISTICS | DEPARTMENT OF DESIGN SCIENCES
FACULTY OF ENGINEERING LTH | LUND UNIVERSITY
2016

MASTER THESIS



FLEXTRUS
a member of the AR Packaging Group



FIPDes

Food Innovation & Product Design

This Master's thesis has been done within the Erasmus Mundus Master Course FIPDes, Food Innovation and Product Design.

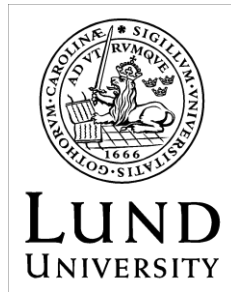


FIPDes has been funded with support from the European Commission. This publication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

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Published by

Department of Design Sciences

Faculty of Engineering LTH, Lund University

P.O. Box 118, SE-221 00 Lund, Sweden

Subject : Food Packaging Design (MTTM01)

Division : Packaging Logistics

Supervisor : Christina Skjöldebrand

Co-supervisor : Ronny Gimbe and Anja Sandberg (Flextrus AB)

Examiner : Malin Olander Roese

This Master's Thesis has been done within the Erasmus Mundus Master
Course FIPDes, Food Innovation and Product Design

www.fipdes.eu

ISBN 978-91-7623-888-2

Abstract

Changing demographics in most of western society bring a range of new demands in the field of food and more specifically in food packaging. The need for convenience is one of the biggest drivers behind many innovations over the past decades. Current trends involve psychological convenience on environmental aspects, as well as ease of opening. Easy to open packaging is desirable because consumers want hassle-free access to the product.

Cheese can be considered as a staple in the Swedish market. A consumer study conducted as part of this project shows the difficulties elderly people have in opening of current packaging of cheese products. That highlights the need to develop a new innovative and convenient packaging solution for cheese products.

The new packaging solution is a modification of current cheese packaging, by integrating PopPack[®] technology. This technology involves a bubble compartment in the packaging that will break the seal as it is popped, providing the tabs that consumer can hold as a grip while opening the package.

The nature of this study is an exploratory phase of a development project with use of design thinking approach. Design thinking makes human aspects as its main focus, makes it suitable for this project in order to base its early stage on the consumer needs.

Investigations carried out to learn the impact that different bubble shapes have on the performance of the solution. The results of this work suggest the best performing bubble shape (among the tested three, which are generated from the ideation session) along with the best top/bottom web materials combination. Also some assessment of the compatibility of design thinking approach in such project.

Keywords: cheese packaging, food packaging development, packaging design, plastic packaging, design thinking

Executive Summary

Introduction

The population is ageing, especially in western countries. The baby boomers that were born post-World War II, are in their fifties now – if not older – serve a large group in the market. Increased demands on convenience along with environmental sustainability are among the biggest trends nowadays. And when it comes to food, prepacked food that has been growing over time has to encounter a big challenge in its packaging, especially the primary packaging that will be handled by the consumers.

With a big leap in the 1970s when there was a campaign of six to eight sandwiches a day by the Brödinstitutet (Swedish Institute of Bread), the cheese consumption in Sweden keeps on increasing over time. This made cheese to be considered a staple in Sweden, especially the range of Swedish block cheeses. These cheeses are packed in colour coded packaging, making it highly limited in the terms of graphical designs. Having a distinct feature on the packaging can be a way to stand out in the market.

Considering the need of convenience, easy to open is one aspect that is widely observed. This is also supported by the fact that ISO just established ISO 17480:2015 on Ease of Opening in the end of 2015. Applying easy to open feature on block cheese packaging in Swedish market can be a way to stand out in the market.

PopPack[®] is an easy opening technology involving an additional bubble compartment within the packaging. The main idea is to burst the seal around the bubble as it is popped to provide separated opening tabs to grip. There is no commercially available product using this technology, it could be a challenge in assessing its effectivity.

Design thinking approach is used in this project. Being a human-centered methodology, design thinking can be a good approach in conducting such a project, where the human factor is crucial. Primary packaging is a part of

consumption unit; therefore the consumer's perspective is important to assess how the solution will perform in the market when it is launched.

Objective

This project is carried out in collaboration with Flextrus AB, a packaging supplier in Sweden, who has the authority to implement the PopPack[®] technology on their products. With a focus on block cheese product, the main objective of this project is to develop a new easy to open packaging solution to cater the needs of elderly consumers in Swedish market. The elderly market is chosen based on the assumption that if the solution works well for them, it will work for other user group as well; also because of the reason of greying population of western countries.

Design thinking approach is used in this project, aiming to evaluate its compatibility in carrying out a food packaging development project. This approach is deemed suitable for this project, given the nature of exploratory phase in development project where the direction of the project is defined. With design thinking, this development project puts consumer needs in priority, on top of technical and business aspects.

Method

Among several design thinking theories available, this project used the one established by Hasso-Plattner-Institut School of Design Thinking with six iterative processes, namely *understand*, *observe*, *point of view*, *ideate*, *prototype*, and *test*. Iterative process means that the evolution of the project might or might not be linear from the beginning until the end. The iterative nature allows the project to switch from one phase to another accordingly to the findings.

In this project, only one iterative process occurred due to the time limitation. In the *understand* phase, the researcher conducted literature studies and expert interviews. During the *observe* phase, a consumer study was conducted. Persona, consumer journey map, and definition of problem fields were done on the *point of view* phase. Brainstorming session followed by clustering and idea selection was conducted during the *ideate* phase. In *Prototype* phase, prototypes of the winning

ideas from *ideate* phase were made. Continue to *test* phase, both quantitative and qualitative tests were carried out to assess the performance of the prototype both subjective- and objectively. Another prototyping was done to improve the winning solution based on the series of tests carried out before. This sent the project back to *prototype* phase. The iterated prototype was the tested during pitching to the manufacturer in the last *test* phase in this project.

Results and Discussions

In the *understand* phase, the researcher gained understanding about the current cheese packaging solution, trends in food technology, as well as the understanding upon the PopPack[®] technology. To enrich her knowledge, the researcher did a direct contact and observe the consumer behaviour toward the current cheese packaging solution and the PopPack[®] Prototype 0 during the *observe* phase.

Having all the needs gathered, researcher built a list of needs expressed in persona and consumer journey map in the *point of view* phase. In the end of this phase, a problem fields were established, giving the further direction for the next phase. The problem fields are the main aspects to be considered in making the solution, they are listed as follows;

- Easy to open function (popping)
- Good popping sound
- Low peel force
- Attractiveness (fun shape, aesthetic standpoints)
- Easy to understand concepts

The problem fields were then turned into brainstorming questions in the *ideate* phase. The ideas generated were then clustered into six different groups as follows;

- Commercial and widgets inside bubble
- Graphical designs
- Bubble designs
- Bubble position
- Materials
- Sealing/Peel

After a voting, the ideas that will be looked into further is the bubble designs, then the ideas in this cluster was mapped into an impact-effort matrix. The best ideas

were then discussed further for the technical details on prototyping. Four bubble designs were decided to be tested in the prototypes.

The *prototype* phase started with manual prototyping in Flextrus AB's prototyping laboratory. The attempts taken here were not working because of the sealing failure. Then the prototyping was continued on the pilot scale, utilising the form-fill-seal machine in PackDesign AB's facility. Only three bubble designs were included in the prototype due to the machine limitation. There were three different material combination and/or process conditions tested, giving this project three different prototypes with three bubbles on each, resulted on nine samples to be tested (bubble A in P1, P2, and P3; bubble B in P1, P2, and P3; and bubble C in P1, P2, and P3).

In first *test* phase, there were two qualitative tests and two quantitative tests carried out. The first qualitative test was the scoring test, resulting on the compatibility of each sample to the problem fields established before. The second qualitative test was the popping test as suggested by PopPack LLC. This test gives the result on which design is the most success in the term of making the popping sound and bursting the seal. From these qualitative tests, the best performing sample is bubble A on P2.

The quantitative tests include popping force and peeling strength. Both were done on machines, resulting on a graph of force needed to pop the bubble or peel the packaging (separate top and bottom web). Unfortunately, the best performing sample in these tests were not quite conclusive, due to lack of actual range of nominal forces desirable. But based on several approaches around it and insights gathered from experts, it was decided that bubble A on P2 still performs better than the others.

Bubble A on P2 is the winning idea. To improve this sample, this project was sent back to *prototype* phase. A technical iteration was carried out in order to manipulate the seal strength around the bubble. Given the limited duration, similar tests could not be carried out for this iterated solution as it was done from the previous samples. Instead, on the last *test* phase, the iterated prototype was shown to the cheese manufacturer and feedbacks were gathered for further development of this project.

Conclusion and Recommendation for Future Work

Among the three tested bubble designs, bubble A performs the best among the other bubble designs and P2 gives the best material combination and process conditions.

Design thinking approach is a good method to be used in this kind of project, resulting on an in-depth understanding about consumer needs, therefore giving the project an orientation to start with. Some challenges were faced during the ideation/brainstorming session but the whole process was worth the experience of introducing design thinking into this project.

Further studies can be carried out in the exploration of applying the PopPack[®] on to reclosable packaging material, since there was a demand of reclosability in the cheese packaging through the consumer test. Trying it on a semi rigid packaging solution can also be a way to broaden the range of products in which PopPack[®] can be implemented.

Suggested by the cheese manufacturer, the bubble should be located in the sharp corner of the cheese packaging. This will impact the angle of peeling, therefore it is necessary to proof that bubble A will perform as good in different angle.

Investigating the possibility of implementing the solution on the packaging line of block cheese, including the machine flexibility to assist the change of reel size is important. Another solution could be by changing the machine in packaging line, or changing the size of the cheese. Both alternatives are costly; therefore an investigation needs to be done.

Establishing a range of the nominal force so that the solution has a more defined goal for the development is also important. Another consumer study to see the acceptance of the solution, as well as testing methods of educating consumer (i.e. imitating commercial videos) are necessary before the solution is launched.

Acknowledgments

Twenty weeks of carrying out this thesis had been a great learning process for me as a researcher. A rare opportunity to be involved in the early stage of food packaging development process had enriched my experience and knowledge in a lot of different ways.

I would like to express my gratitude for the time, effort, guidance, and support from my academic supervisor, Christina Skjöldebrand. A big part of this project that was carried out in the facility of Flextrus AB was only made possible by the huge effort put together by my industrial supervisors – who are also my colleagues and friends – Ronny Gimbe and Anja Sandberg. I am grateful for having my supervisors during the process of this Master Thesis Project because without them, I will never get the feedback and connection to the resources I needed.

Highly appreciated are the inputs I got for this project. To the experts from Flextrus AB; Bobby Micevski, Jimmy Anderberg, Håkan Arnfors, and Marina Bergin for valuable information and help on the manufacturing site as well as the laboratory. Special thanks to Pär Bierlein from ÅR Carton's and Roger Kalitta from Packdesign AB, for the help on running necessary equipment. Also thanks to William Perell and Cheryl Harrison from PopPack LLC for a short yet very informative meeting.

I would not have this opportunity at the first place without the FIPDes consortium, great team in Paris driven by Barbara Rega, Dublin energetic team; Anna Cruickshank and Roisin Burke, and amazing “Dads” in Lund; Erik Andersson and Daniel Hellström, and other FIPDes teams that are not mentioned here.

My support system in Europe, Jonas, Hannah, Caro, Jenya, Moni, Dani, and all FIPDes Fantastic 4.0, thanks for being there when I needed someone to share with. Thanks to Devi and Darwin who tried to understand my problems and struggles from across the ocean. And last but not least, thanks to my family.

Lund, June 2016

Santika Karunika Chenderasa

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List of Abbreviations

AB	: Aktiebolag (Swedish term for limited company)
CEN	: Comité Européen de Normalisation (French for “European Committee of Standardisation”)
DC	: Dry Content
DT	: Design Thinking
e.g.	: <i>exempli gratia</i> (Latin for “for example)
i.e.	: <i>id est</i> (Latin for “in other word)
ISO	: International Standard Organisation
LLC	: Limited Liability Company
MAP	: Modified Atmosphere Packaging
sec	: seconds (time unit)
TC	: Total Content

1. Introduction

This part of the thesis explains about the current situation and how it drives the project to focus on certain directions as well as the approach used in this project (design thinking). The purpose and aim of this project are discussed here too.

The population is greying. This is a main challenge that most of the western countries have to face. Since there was a massive increase of birth post World War II, Eurostat report (Lanzieri, 2011) stated that until 2060 a significant ageing of the population will be seen. There were approximately three youngsters (0-14 years old) for each elderly (above 65 years old) in 1960 and it is expected to be two elderlies for each youngsters in 2060 (Lanzieri, 2011). A higher chance of survival from sickness due to development of medical systems also contributes to this situation (Robine and Michel, 2004). As a result, current market is dominated by baby boomers (born around 1948-1960) that are in their fifties if not older. This make them an important target of marketing a product in this aging world (Mumel and Prodnik, 2005; Niemela-Nyrhinen, 2007; Thompson and Thompson, 2009). The biggest demand from them is convenience and improvement of the packaging is a way to go since it is deemed as a powerful marketing strategy (Guss, 1967).

One of the most emphasised aspects of convenience on packaging is the ease of opening. Several standards were published, showing the urgency and increasing demand of a packaging that is easy to open. Started in 2011, a European Technical Specification for ease of opening in packaging (CEN/TS 15945) was established, and later adopted by British Standards in 2014. The latest is an international standard established by International Organisation of Standards in ISO 17480:2015 (International Standard Organisation, 2015).

As suggested on the ISO 1748:2015, convenience study may put focus on elderly people. Having physical limitation, this group is considered as a good benchmark. If the solution is working well with this group, it will be most likely to work on other groups as well. Supported by the fact that this group serves a large portion of

the current market, this study is focused on catering their needs of easy to open cheese packaging.

1.1. Easy to open Packaging Solution

Standards have been established on ease of opening, meaning these set of criteria has to be fulfilled in order to get the easy to open claim on a product’s packaging. ISO 17480:2015 includes a checklist for conformance to the related standard. In summary, the aspects coverage is shown in Table 1 below;

Table 1. Summary of Checklist for Conformance with ISO 17480:2015

Aspect	Requirements
Context of use	<ul style="list-style-type: none"> • Consideration on packaging design to deliver the main goals of the packaging and the tasks needed to achieve them • Human and environmental factors during usage are taken into account
Opening strength	Achievable nominal force
Dexterity	Packaging is easily manipulated by the consumer
Cognition	Opening system is easily understandable by the intended consumer
Opening location	Readily found opening
Methods and mechanism of opening the package	Easy to identify and understand the opening method
Force and handling aspects	Accommodate force and dexterity range given by different groups of consumers
Reclosing the package	Easy to reclose the package

Concluded from this checklist are two most important values of easy to open packaging; intuitive usage and physically possible to be opened. These values are easy to comprehend but to fulfil them, some technical details down to the smallest ones need to be taken care of. Tactile stimuli, graphical design, shape of opening

site as well as the size, and also font size are some approaches suggested in the ISO 17480:2015.

Having the ISO as a starting point, this project is evolving around it. Suggestions given in the ISO for different testing and design are taken into the consideration throughout this project, so that the final idea may readily meet the requirements and possible to be claimed as easy to open packaging.

The easy to open technology used in this project is patented as PopPack[®], by PopPack LLC, a company based in the United States of America. The solution includes a bubble compartment in the packaging that will help separate the tabs by breaking the seal as it is popped.



Figure 1. PopPack Technology (source: <http://www.poppack.com/>)

1.2. Cheese in Sweden

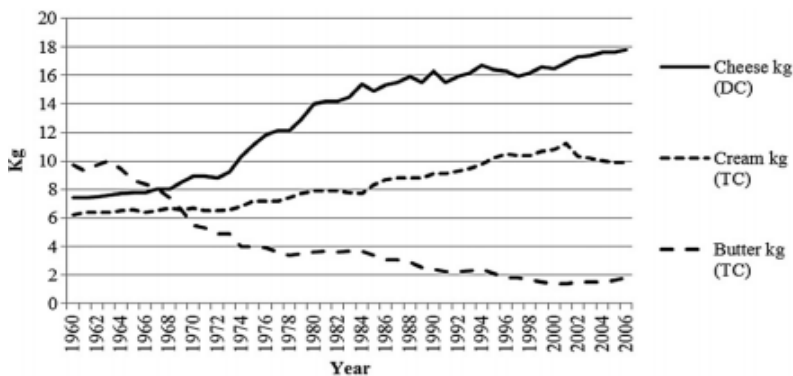


Figure 2. Consumption of dairy products in Sweden (Geeraert, 2013)

Over decades, the cheese consumption in Sweden has been increasing in comparison to other dairy products. Shown in the Figure 2, the consumption of cheese was more than doubled in 2006 from it had been in 1960. There was a big increase in the 1970s and this is not without a reason. Around this period, Swedish Institute for Bread (Brödinstitutet) made a classical campaign in giving recommendation to consume 6-8 sandwiches a day (brodinstitutet.se, 2016). This entails the increase of cheese consumption since it is very common to eat bread with cheese in Sweden. Ever since the boom in 1970s, the consumption of cheese in Sweden still keep going up, showing that most of the Swedish population has deemed cheese as a part of their staple in their daily life.

Herrgård[®], Präst[®], Greve[®], and Hushållsost are the most popular cheese types in Sweden. To help customer distinguish one from another, the packaging are colour coded. Herrgård[®] is recognised from its green coloured packaging; Präst[®] is packed inside black coloured packaging, Greve[®] in blue, and Hushållsost in red. (matochdrycker.se, 2016). This limits the graphical design on the cheese packaging. Therefore, additional features on the packaging can be a unique selling point for the cheese brands.



Figure 3. Swedish cheeses packed in colour coded packaging

Block cheese is normally found in the refrigerated section in grocery store, cut in a triangular shape as a part of the whole wheel of cheese produced. The individual pack has the weight of around 500 grams. From several preliminary interviews done at the very first phase of this project, researcher learned that customers often cut the cheese packaging with a knife or scissor and then keep the cheese in a plastic box/container. This means that the life cycle of the packaging is very short and the product lost its brand almost right after the product is bought.

Utilisation of sharp tools to open the packaging is because customers find it hard to open it by hand. Sometimes the “open here” tabs (öppnas här in Swedish), as shown in Figure 4, are stuck together, and separating them needs so much precision and effort. This shows there is a recognised need of easy to open packaging for cheese product. To be specific, to get a grip on both upper and bottom tabs easier.



Figure 4. Open here tabs on cheese packaging

1.3. Design Thinking in Food Packaging Development

Quite frankly explained by the name, design thinking (DT) is an approach to innovation using some principles of design (Brown, 2008). This has been a widely used approach in different businesses, started with tangible products and now implemented in the intangible ones (Brown and Martin, 2015).

DT approach had started to be introduced in the field of food innovation (Olsen, 2015), resulting on better understanding of what the consumers actually want from a food product. The main core of DT is the human-centered approach (Brown, 2006; Holloway, 2009; Ward, *et al.*, 2009). As stated by Brown (2008), the way a product is packaged will affect the consumer’s feelings about a product. Putting it all together, this project is based on a human-centered design for food packaging development process.

Throughout the project, the researcher utilised DT approaches. This means the next step of the project is defined by the outcome of the previous one, rather than planned from the very beginning. This approach is considered as the best way to cater as much consumers' needs as possible, given the novelty of technology implemented in the packaging in which all the potentials are to be explored. Considering the flexibility of DT approaches, the researcher is confident that DT fits such a project.

1.4. Aim of This Thesis

The main objective of this thesis is to develop a new opening system on packaging solution for block cheese product by implementing the bubble feature as introduced by PopPack[®] to cater the need of easy to open packaging by elderly customers in Swedish market with an approach of DT process.

Different activities carried out throughout this project are fitted to the DT processes. The outcomes are expected to answer the following questions:

- What is the best way to implement PopPack[®] technology on block cheese packaging?
- How might DT approach be useful in development of food packaging?

The research is conducted in collaboration with Flextrus AB, a packaging supplier based in Sweden that has the authority to implement the PopPack[®] technology on their products. The output of this research is expected to be in line with further development by the company for this solution with possibility to get an easy to open claim on this particular product as integrated.

Hypothetically, the integration of bubble compartment to the cheese packaging will make it easier to open, even by elderly customers. And the utilisation of DT process, being a human-centred approach to innovation, will make the solution more effective in addressing the consumer demand of easy opening.

1.5. Focus and Delimitations

This study is focused on an easy to open cheese packaging for elderly people, as they are considered as the largest group in the market and also because they have physical limitations. Assumption is made based on the fact that if this solution

works well for them, it should work even better for other market groups. The consumer market here is limited to Sweden with extension to other Scandinavian countries. This limitation is dependent on the market coverage of the industrial partner – Flextrus AB – for cheese packaging. Focus is put on the primary packaging of the product.

From the wide range of cheeses available in the Swedish market, this project used Herrgård® cheese as samples in the customer study. Preliminary observation and interviews had shown this particular cheese type as one of the most consumed, so it is deemed as a good benchmark.

This project is still in the exploratory phase of the whole project owned by Flextrus AB. Therefore, the nature of this project does not allow the researcher to go in depth on theoretical aspects related to this very specific technology of cheese packaging with PopPack®. Most of the processes are based on discussion with experts in both Flextrus AB as well as PopPack LLC. Prototyping was carried out on a trial and error basis, which will be discussed further later on in this document.

Also related to the nature of this project, DT is considered as the most suitable innovation methodology since the next step was decided *on-the-go* as the project evolved, considering a flexible approach but within defined constraints. The researcher does not speak Swedish. Since DT is a method that works really closely with the user, the language barrier limits this project. Fortunately, there were colleagues from Flextrus AB as well as supervisors that helped with the translation both orally and written (e.g. in making the questionnaire).

The limited duration to carry out this project also limits the project to some extent. Especially with the DT approach where iterative processes are key, the time limitation defined how much iteration can be coped into the scope of this project. The researcher hoped that in the continuation of this project, DT approaches will still be used; therefore introducing it to the project while it is still on its early phase is important.

1.5. Outline of Thesis

This thesis consists of five different chapters;

- Chapter 2 *describes the frame of references grounding this project. This includes the evolution of food packaging, cheese, DT and about the PopPack® technology.*

- Chapter 3 *explains the methodologies used in different phases of this project.*
- Chapter 4 *is where the results of the researches are shown and discussed in line with the DT methods. Also the critiques about this project can be found here.*
- Chapter 5 *concludes the works of this project, recommendations on further development for the company, as well as suggestion for further research in application of DT for food packaging development projects.*

2. Frame of Reference

This project is grounded on some theories and findings from previous studies. In this chapter, the relevant references are discussed, related to the evolution of packaging innovation, cheese and the packaging of cheese, DT and the PopPack® technology. The purpose of this chapter is to guide readers to put this project in a frame alongside with all the existing knowledge.

2.1. Food Packaging Innovation

Innovation and development in the field of food have been oriented towards processing food products more conveniently, more efficiently, at less cost, and with higher quality and safety levels (Han, 2005). Another field of development that is not to be neglected is food packaging, since it has a high potential of being a competitive advantage in the industries (Coles, *et al.*, 2003).

Han (2005) stated that packaging design and development includes not only the industrial design fields, creativity and marketing tools, but also the areas of engineering and environmental science. This statement is supported by some necessary conditions as discussed previously (Yokoyama, 1985) for an appropriate packaging, which are:

1. Mass production
2. Reasonable and efficient packaging material
3. Suitable structure and form
4. Convenience
5. Consideration of disposal

The aspects of convenience on food packaging has been evolving through the time, some significant development mentioned in Coles, *et al.* (2003) are shown in the Table 2 below.

Table 2. Convenient Packaging Trends

Era	Trend	Products
1800s	Heat resistant (for sterilization purposes)	Glass jars
1890s	Machine able	Machine made bottles
1930s	Individual portions	Canned beers
1940s	Ready-to-use	Aerosol for spray dessert toppings
1950s	Easy to use	Squeezable
1970s	Ready-to-prepare	Boil-in-the-bag, microwaveable
1980s	Multipurpose	Can-to-vessel beer packages, retortable-microwaveable
1990s	Aesthetic	Printable packaging materials

More recent studies show that the definition of convenient still keeps changing. Some keywords to describe convenient nowadays are easy-to-use (Lingle, 2012), easy to understand the quality (Park, 2015), and easy to open (Han, 2005; Gates, 2007). This is highly related to the ageing of population since the Baby Boomers are now in their golden age.

Increasing demand of easy to open packaging is also proven by the publication recently made by International Standard Organisation in 2015. The ISO 17480:2015 specifies requirements and recommendations for the accessible design for easy to open packaging. Some considerations suggested in this standard is shown in the Table 3 below.

Table 3. Suggestions from ISO 17480:2015

Aspect	Main Criteria
Opening location	Easy to differentiate by visual and tactile markings
Methods and mechanisms of opening the package	Clearly evident method, independent of the size or power from the consumer, prevent spillage
Force and handling	Includes wide range of different strength and dexterity of different consumers
Reclosing the package (optional)	Easily understood and smooth re-opening

Given the current demographic situation as mentioned in the previous chapter, supported by previous studies and publications, easy to open packaging is a development to be taken into account seriously both by food and packaging manufacturers.

2.2. Cheese and Its Packaging

Back in time, cheese was made on household basis, where the fat from milk was skimmed off and processed into butter while the rest was processed into cheese. As trading started to be involved in daily life, a local trading of cheese was also started. Locally traded cheeses are covered with wax to reduce the contact with environment. Only in around 1940, the Cryovac[®] vacuum packaging system was introduced in cheese that by then was already an industrial commodity. The next development of cheese packaging was in 1980s, when the Hayssen machine introduced, allowing a modified atmosphere packaging (MAP) solution. This method involves a modification of the gas composition inside the packaging. In the case of cheese product, it is done by injecting pure nitrogen (N₂) into the packaging (nationalhistoriccheesemakingcenter.org, 2016).

Cheese packaging is expected to serve all the standard pre-requisites of the packaging. As mentioned by Lockamy III (1995), the six main functions of packaging are containment, protection, apportionment, unitization, convenience, and communication. Specifically for food packaging, Kelsey (1985) mentioned functions of protection, containment, information, and convenience. Additionally

to these functions, due to the characteristics of the cheese product, there are two other functions required for a good cheese packaging, including prevention of dehydration that leads a consequent weight loss, as well as protection from undesirable odors from the environment (Garabal, *et al.*, 2010). This is why plastic material with good barrier properties has served the role of packaging material for most of the cheese products till date.



Figure 5. Example of current Herrgård cheese product's packaging

Application of MAP in cheese packaging has also been improved over time. As mentioned above, firstly, nitrogen gas was used in the cheese packaging as it is an inert gas and may act as filler to avoid the collapse of the packaging (Robertson, 1993). Improvement was focused on introducing another gas, in this case, the carbon dioxide (CO₂). A study dated back to 1982 carried out by King and Mabbit had mentioned about the potential of this gas to extend shelf life of dairy products (study was applied on raw milk) by prolonging the lag phase on bacterial growth. Later study shows that flushing CO₂ before sealing a cheese packaging can inhibit mold growth (Farkye and Vedamuthu, 2002). Due to its active property, CO₂ is commonly added to the packaging of cheese product in different ratios to the N₂ gas (Garabal, *et al.*, 2010).

Form fill seal is a commonly used term to refer to a specific technology of packaging. Developed since around 1970s (Coles, *et al.*, 2003), this technology brings a lot of advantages since it will allow industries to increase process efficiency (larger volume in shorter time), as well as improves the logistics of packaging material. Form fill seal machine has the capability to form the packaging just before it is filled with product, therefore the packaging material can be transported in a more compact form (Rowan, 2000). In the case of cheese, high barrier plastic material is transported on reels. On the producer's site, it will be formed - either vacuum or blow forming methods - into the desired shape. Later,

this formed packaging is filled with cheese, flushed with nitrogen and/or carbon dioxide gasses, and then sealed (Micevski, 2016).

Due to its triangular shape, block cheese products were packed in a certain pattern so that it can be cut into individual packages easily with straight knives.

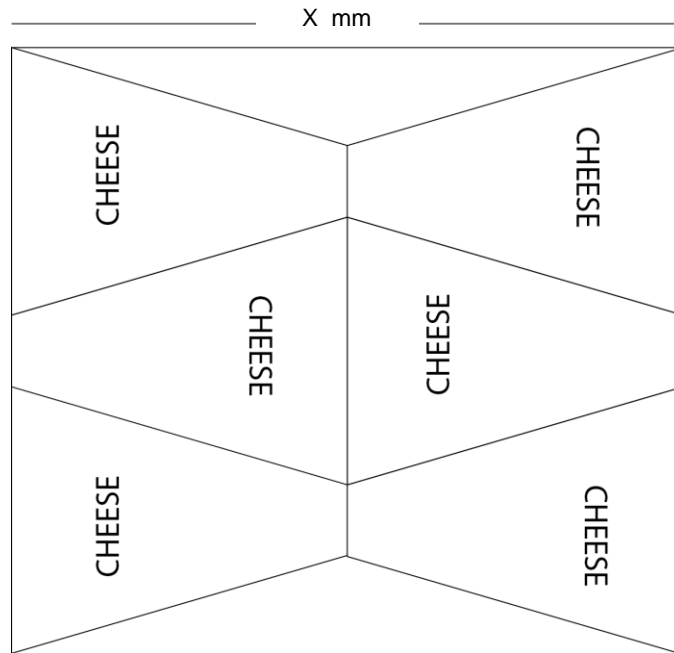


Figure 6. Cheese packaging pattern on reel

The measurements of the reel are set by the clients depending on the size of reel holder in their packaging line. For example, a dairy industry in Skåne area, Sweden demanded the reel to be X mm wide (real value is confidential), with shapes shown in the Figure 6. The length of material in a reel went up to couple hundred meters, providing material for thousands of cheese packages. Reels of materials sent out from Flextrus AB are stacked on top of each other, creating two layers of reels, arranged in a vertical position on an EU pallet with a total of sixteen reels per pallet. Pallets are then delivered by a freight forwarding company to the cheese manufacturing plant, to be installed in the form fill and seal machine (Bergin, 2016).

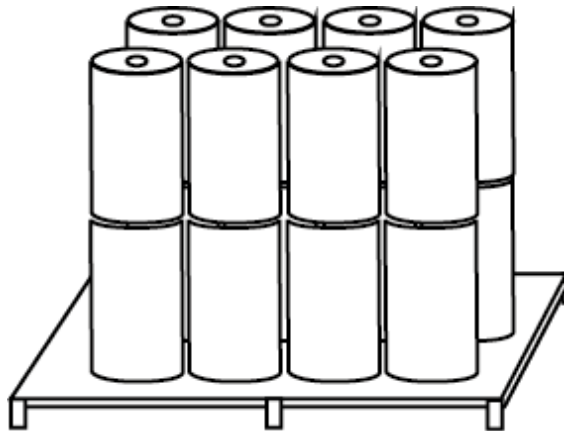


Figure 7. Arrangement of reels of cheese packaging material on a pallet

2.3. Design Thinking

As mentioned in Chapter 1, DT is an approach that involves design principles to innovation process (Brown, 2008). Kolko (2015) explains these design principles as:

- Focus on users' experiences, especially their emotional ones
Take into account consumers' emotional value in every touchpoints of interaction with the product.
- Create models to examine complex problems
Sketches and diagrams are used as a tool to explain complicated problems.
- Use prototypes to explore potential solutions
Publicly display a solution and receive feedbacks upon it so iteration can be done quickly.
- Tolerate failure
It is rather rare to get the first thing right. Failures are to be considered as iterative process in which the solution is improved.
- Exhibit thoughtful restraint
Customer is the main concern. A product may even seem to be less functional than one of competitor's when it is for the purpose of making it simpler for consumer to understand.

Kolko (2015) emphasised that DT is a way to simplifying and humanizing. Clark and Smith (2008) assured that DT can bring value to some parts of business. Since

it is based on the user's experience, this method can really be adopted in almost every aspect of a business, but yet, it has only been narrowly practiced in accounting, human resources, and legal affairs (Clark and Smith, 2008).

2.3.1. Models of Design Thinking

Being a widely adaptable methodology, DT is built into several different processes. There are some theories of DT established by different institutions and firms. Below are the three most common ones.

2.3.1.1. IDEO

IDEO is a design and consulting firm based in United States of America, working closely with innovation through DT. The theory suggested by Tim Brown (2008), CEO of IDEO, is shown in Figure 8.

This theory consists of three stages that Brown (2008) introduces as a “system of spaces rather than predefined series of orderly steps”. These spaces can be used accordingly to conduct series of steps needed according to the project itself.

Inspiration is the first, where exploration about the problems and current situations are assessed. Understanding consumer is highly suggested in this step. Stage two is the ideation, where brainstorming and prototyping take place. Prototype testing also happens in this stage where several iterations might occur until the prototype is as close as the final solution and satisfies the users' needs. And the last stage is integration with marketing team to implement the solution.

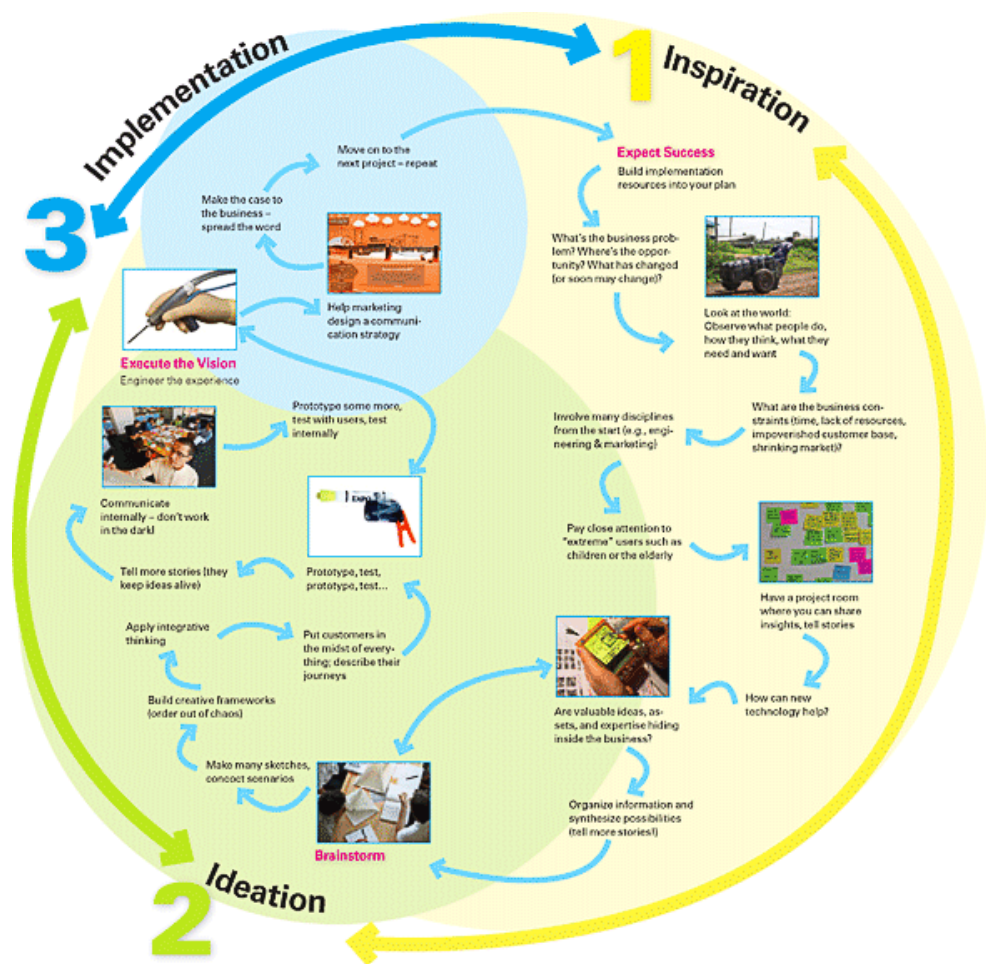


Figure 8. Design thinking process by IDEO (source: Brown, 2008)

2.3.1.2.Hasso-Plattner-Institut (HPI) School of Design Thinking

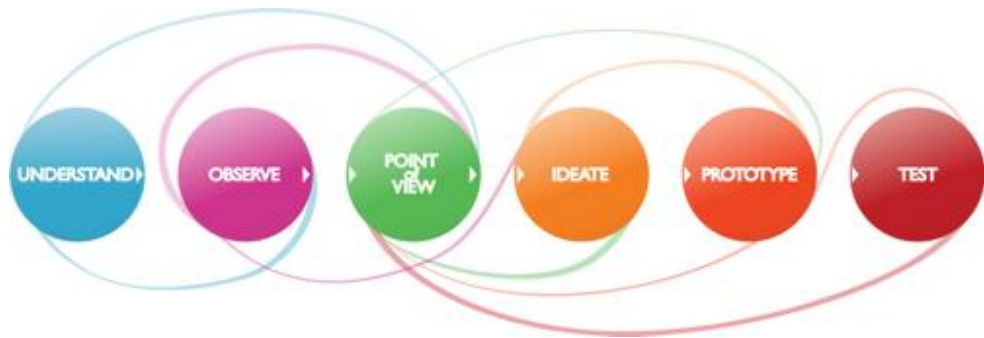


Figure 9. Design thinking process by HPI School of Design Thinking adopted from d.school: Institute of design at Stanford

(source: https://dschool.stanford.edu/groups/k12/wiki/17cff/Steps_in_a_Design_Thinking_Process.html)

Coming from Europe, Hasso-Plattner Institute, a university based in Potsdam, Germany adopted a framework suggested by d.school: Institute of Stanford, America. This theory proposed six stages of DT, namely: *understand*, *observe*, *point of view*, *ideate*, *prototype*, and *test*. This process is derived from Brown's theory of DT (IDEO) discussed in the previous subchapter. This theory made into more detailed stages, where the first three stages are derived from Brown's inspiration space, while ideate, prototype, and test falls into Brown's ideation space.

The first step is to *understand* the situation based on own knowledge, expert interview, and literature studies. *Observe* stage encourages direct contact with users to empathise their feelings and emotional values towards a product. The findings in the first two stages are then analysed to build a *point of view* as for the direction of the project. Starting from the point of view, ideas are generated in the *ideate* stage. (Some or all of) these ideas are then translated into *prototype* to see how it works. Then the prototype is ready for *testing* with targeted audience, and iteration suggestions will send the process back to prototyping again, back and forth until the solution is deemed satisfying (Plattner, 2010).

It is important to remember that DT is a non-linear process in which there will be iterations that sends the team to different phases, either back or forward (Brown, 2009). This is why there are curves around the process bubbles shown on Figure 9, to remind the viewer that the process may create loops until the best solution is achieved.

2.3.1.3. Rotman School of Management

Based in Canada, former dean of Rotman School of Management, Roger Martin proposed DT as a cyclic process. In this cycle, one should switch from one mode of reasoning to another, named abduction, deduction, and induction.

Abductive reasoning involves the realisation of new ideas could not be proven using past data, directing that there is a need to understand the current situation and build new set of data to generate new ideas. In the other hand, deductive and inductive reasoning utilise available data gathered in the past and requires analytical thinking. Deductive reasoning started from general to specific (i.e. using accepted premises to predict future action) while the inductive is from the opposite (i.e. using empirical data to predict future action) (Leavy, 2010).

Introducing the abduction into the cycle of DT goes along with Martin's statement (Dunne and Martin, 2006) about designers are working on project basis rather than permanent assignments, meaning that once the project is done, it "disappears". The next project will be done from the beginning again, including the data collection instead of using the data from previous project.

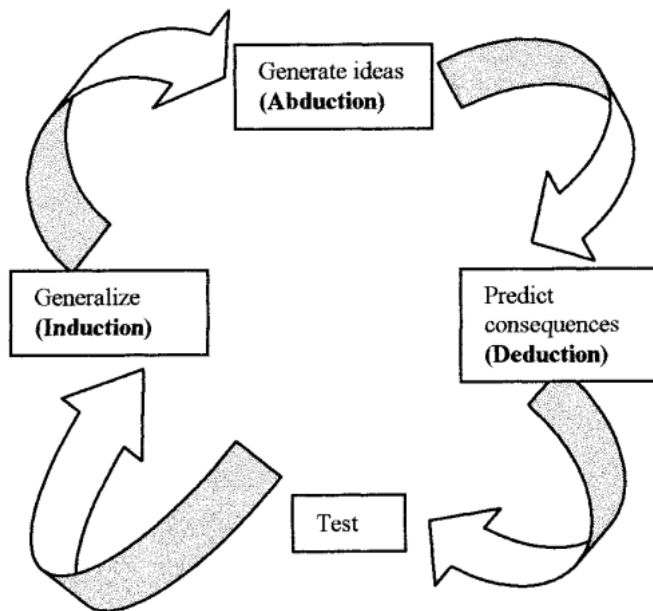


Figure 10. Design thinking cycle in Rotman School of Management
(source: Dunne and Martin, 2006)

2.3.2. Design Thinking Mindsets

Back to a decade ago (Dodgson, *et al.*, 2005), innovation literature has discussed about how design gained more and more importance as an integral capability of innovation and adaptation. This is reflected on how companies are integrating DT into their managerial issues in the organisation and assess the synergy between strategies, on top of the common practice of DT in product and service development (Martin, 2010; Bucolo *et al.*, 2012).

Some companies tried to change flexible process of DT into a rigid plan that fits to the efficiency-based process they are familiar with (Nussbaum, 2011). This might not give the outcome expected from DT, therefore establishing the culture and mindsets of DT are necessary to ensure success of the project (Kimbell, 2012). Schweitzer, *et al.* (2016) discussed about the eleven design thinking mindsets that are important to be adopted upon application of DT, as illustrated in Figure 11.



Figure 11. Visualisation of the design thinking mindsets
(source: Schweitzer, *et al.*, 2016)

In their article, Schweitzer, *et al.* (2016) gave the explanation of each symbol featured in the visualisation (Figure 11) as follows:

1. *Empathetic towards people's needs and context*
Understanding users' feeling and appreciate their emotional values, to create emotion-rich innovation (ibid. p. 6-7).
2. *Collaboratively geared and embracing diversity*
DT projects often include multi-faceted problems, demanding different experts in the team to result on an all-inclusive solution. This might be a challenge since people may differ on their perspectives due to the field of proficiencies. Therefore, mindsets of willingness to collaborate and embrace the diversity are necessary for DT project's teams (ibid. p.7).
3. *Inquisitive and open to new perspectives and learning*
Mentality of keep questioning the findings along the project will develop a solution that can address the problem to the best extent (ibid. p.7-8).
4. *Mindful of process and thinking modes*
Evolving through stages of DT meaning that the team has to switch from one thinking mode to another to be sure that they get what they have expected from the stage in question (ibid. p.8-9).
5. *Experiential intelligence*
Trial and error during the making and the testing of the solution mock up is an important learning tool in a DT project (ibid. p.9-10).
6. *Taking action deliberately and overt*
Action oriented spirit rather than analytical one (ibid. p.10).
7. *Consciously creative*
Creative understanding is important in DT framework, especially for acknowledging mistakes, minimizing hierarchy, and encouraging imagination without being quantitatively predictive (ibid. p.10-11).
8. *Accepting of uncertainty and open to risk*
DT projects are often started with an unknown outcome; therefore uncertainties are very likely to occur during the process (ibid. p.11-12)
9. *Modelling behaviour*
The attitude of the team plays a crucial role in design thinking projects (ibid. p.12).
10. *Desire and determination to make a difference*
Still related to modelling behaviour, the team are expected to have a high optimism about the project to not giving up through the uncertainties (ibid. p. 13)
11. *Critically questioning*

Since there are a people from different backgrounds are expected on a DT project team, critical questions have to be deployed in order to avoid false decision making (ibid. p. 13)

2.4. PopPack®



Figure 12. PopPack® easy opening solution with bubble compartment
(source: <http://www.poppack.com>)

PopPack® is an innovation that includes bubble-in-the-seal technology, established by PopPack LLC, San Francisco, California, USA. This innovation has been patented in different countries worldwide. This ever growing business has a team of engineers in Japan and collaborative partners around the globe, with Flextrus AB as one of them.

A hand surgeon in The University of California San Francisco (UCSF) Medical Center, Doctor Edward Diao, had proven that PopPack® is an easy to open packaging solution even for patients with arthritis. He explained how PopPack® can be opened with a very flexible angle of elbow and wrist, making it possible to be opened by everyone.

PopPack® had also introduced the solution as a way to add fun aspect to the product. Perell – the managing member of PopPack LLC – shared his experience in conducting a consumer research for children in elementary school who had hard time opening the packaging of cheese string product. The outcome is satisfactory because not only the packaging becomes easier to open for the kids, but also it makes them enjoy the experience of opening the package better, since the popping sound added a lot of fun to it.

Having a solution of easy and fun to open packaging, PopPack® has also been tried in several different types of packaging, such as pouch, pour, tray, and semi-rigid packages. Unfortunately, there is no commercially available product in the market yet with this solution. But with large exploration and scouting of potential products in different markets around the world, it is about time until products in the market has PopPack® bubbles on its packaging.

(information from poppack.com and interview with Founder and Marketing Director of PopPack LLC)

3. Methodology

In this chapter, methods of carrying out the project are discussed. It shows the different activities done in each stage of design thinking process with some theories behind it.

This project adopted the design thinking process proposed by HPI School of Design Thinking. The six steps process is visualised in Figure 13 below.

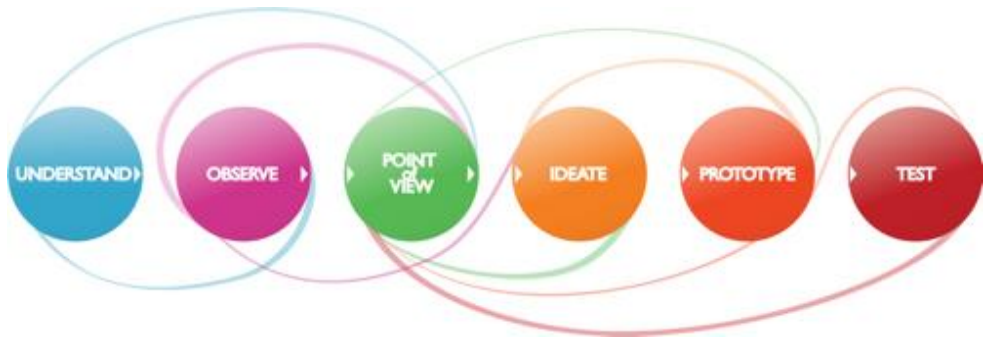









Figure 13. Design thinking process by HPI School of Design Thinking adopted from d.school: Institute of design at Stanford
(source: https://dschool.stanford.edu/groups/k12/wiki/17cff/Steps_in_a_Design_Thinking_Process.html)

Given the limited duration of this project, researcher had the opportunity to carry out the project through all processes, but unfortunately, only one iterative loop was carried out. Neither was carried out in this project scope is the meta-process of implementation (as suggested by Brown, 2008).

It should be kept in mind that there was only limited planning that can be done at the beginning of the project. Activities are outlined before but there were modifications that happened during the process as the project evolved from one stage to the other.

Shown in the Table 4 below are the activities in different phases of this project.

Table 4. Steps and Phases of The Project

Activity	Stage
Literature Studies (<i>Food Packaging Innovation, Cheese, and PopPack®</i>)*	
Literature Studies (<i>Ergonomic Requirements</i>)	
Expert Interview (<i>Internal Sales, Flextrus AB; Managing Member, PopPack LLC</i>)*	
Consumer Test	
Consumer Journey Map	
Persona	
Definition of Problem Fields	
Brainstorming	
Clustering	
Scoring	
Mapping (on Impact-Effort Matrix)	
Manual Prototyping	
Pilot Scale Prototyping	
Qualitative Tests	
Quantitative Tests	
Improving the Best Performing Solution	
Pitching to Manufacturer	

* Results reflected in Frame of Reference (Chapter 2)

3.1. Understand

Understand is the first phase of the DT process suggested by HPI School of Design Thinking. Aiming to assess the aspect and the nature of the problem, researcher carried out some literature studies related to trend of food packaging

innovation, cheese market and history, and about the novel technology - PopPack® - that will be introduced to the solution as requested by the industrial partner.

Also carried out in this phase were several interviews to the experts related to the logistics of current cheese packaging (Bergin, Internal Sales, Flextrus AB) and about the evolution of PopPack technology itself (Perell, Managing Member, PopPack LLC).

3.2. Observe

Observe aims to find out the user needs through direct observation and interaction with the customer. The method used in this consumer test involved a needfinding approach, adopted from the article by Patnaik and Becker (1999).

This approach was introduced by Robert Kim, head of Stanford University’s product design program for the period of 1980s, under the term of Needfinding (Patnaik and Becker, 1999). In their publication, Patnaik and Becker mentioned the importance of Needfinding and how can it help a business to go beyond a development of a single product by recognising the consumer needs. Needfinding looks beyond the immediately solvable problems; therefore, there is no line between the relevant and irrelevant data (ibid.).

The Needfinding process is divided into four main parts with suggested methods on each part as described in the Table 5 below;

Table 5. Needfinding Stages (Patnaik and Becker, 1999)

Frame & Prepare	Watch & Record	Ask & Record	Interpret & Reframe
Frame the research questions	Immerse oneself in the user group	Interview in the customer’s environment	Create need statements
Define the user group	Avoid intrusions to keep the behaviour natural	Record information in the customer’s terms	Classify and prioritize the needs
Study established data for grounding the subject	Use appropriate recording media		Reframe the research

Using the suggested approaches, this part of the project started with some background studies in which the researcher together with academic and industrial experts discussed the Frame & Prepare phase.

Since the selected user group is elderly people, the researcher did not have the opportunity to immerse herself in a participative observation setting. In order to not miss the Watch & Record phase, an observation test was conducted and recorded to capture all the interaction between the elderly consumer with both current cheese packaging and PopPack® Prototype 0. This observation was conducted in a pension meetup, weekly activities in which the consumers have been familiar to. Having the observation conducted in consumer's location is expected to make the consumer more convenient in sounding her opinion as oppose to doing it in a research facility. The panelists consisted of 30 people aged more than 65 years old.

For the current cheese packaging related properties, a sample of commercially available cheese product was given and panelists were demanded to answer the questions based on their experience of using the particular product. After filling out the questionnaire, panelist was led to the booth where opening process of the packaging was recorded. Observations were made based on how the package was opened and where the consumption started.

For the interaction between consumer with the PopPack® Prototype 0, the method proposed in ISO 17480:2015 was adopted. The panelist was given a new packaging (Prototype 0) along with graphical instruction on how to open it (Appendix 2). After the first sample was opened, a second one was handed out to the panelist and again, the panelist had to open the second sample of prototype 0. For both samples, the opening time was recorded. According to the standard, the opening of the first sample of new packaging has to be aborted after five minutes and one minute for the second sample. In the end, panelist's experience with the popping feature was asked. A smiley scale (Figure 14) was used to measure satisfaction from opening the packaging.



Figure 14. Five points smiley scale for hedonic test (Pousette, et al, 2014)

To make sure all the information is framed in consumer's terms, the interview for Ask & Record phase is replaced by questionnaire (Appendix 1), which might not be as effective, but is considered better in order to ensure the consistency of the information gathered due to the limitation of language (the researcher does not speak Swedish).

3. 3. Point of View

In this stage, the data gathered from the *Understand* and *Observe* phases are analysed. The data gathered are then made into a list of needs and presented in a consumer journey map. Profile of the consumer is used to build the persona of the user group. At the end of this phase, problem fields are defined, which would guide the further evolution of this project.

3.3.1. Consumer Journey Map

A consumer journey map describes the touchpoints of interaction between consumer with a product or service on a timely frame. This map includes the needs to improve consumer experience in every touchpoint as well as drives and barrier that can encourage or discourage consumer to move to the next touchpoint (Richardson, 2010).

The consumer journey map was built by participative observation. By playing the role of a normal consumer, the researcher and some respondents (not necessarily from defined user group) discussed about the needs in actions taken on every touchpoint.

3.3.2. Persona

Persona is a profile of the consumer group, built to increase empathy of the project team with their users (Grudin and Pruitt, 2002). This is a way to present the data gathered from *Observe* stage of the project in a way that it is easier to relate to the consumers, therefore the needs are understood better.

3.4. Ideation

Starting from the main goals defined in the previous step, an ideation session was carried out. Trying to include all the aspects of packaging, the participants came from different divisions of the company (Flextrus AB), such as business, product development, technical, engineering, and production.

3.4.1. Brainstorming

Ideation session started with brainstorming. The brainstorming itself is divided into two phases, “brain dump” and discussion (Hartman, 2005). In the brain dump session, participants were introduced to the project and asked to put all the ideas that they had previously had in mind, since most of the participants had been familiar with this technology to some extent. The brain dump session was done individually, with each idea written on separate sticky notes. In the end of the brain dump, participants were asked to put up the ideas on a board and share them with the forum.

The discussion part came after. Knowing each other’s ideas, the moderator launched brainstorming questions which are the five main goals defined from *Point of View* phase. These questions are launched one by one. After launching of each question, a five minutes silent brainstorming in pairs where participants were encouraged to combine different ideas from brain dump session as well as coming up with new ones for a total of at least five ideas per pair, followed by seven minutes of idea sharing after.

Taking part as moderator, the researcher implemented seven brainstorming rules as outlined in IDEO HCD Toolkit (2008), which are:

- Defer judgement – no bad ideas
- Encourage wild ideas – go beyond “normal”
- Build on ideas of others – combining and improving ideas
- Stay focused on topic – discipline participants
- Be visual – engage logical and creative sides of the brain
- One conversation at a time – allow ideas to be heard and built upon
- Go for quantity – set a big goal of number of ideas

3.4.2. Clustering

At the end of the brainstorming session, all ideas were put up on the wall. This clustering process adopted the affinity mapping as suggested by Lepley (1998) with purpose to put the ideas into groups. Six groups are generated, based on which part of the packaging it was improving.

After clusters are made, each participant was given seven stickers that they could put on the ideas they liked the most. Two veto stickers were given out, one to the participant from business division and another to participant from production division. The vetoed ideas continued to the next session, along with other top scored ideas.

3.4.3. Mapping (Impact-Effort Matrix)

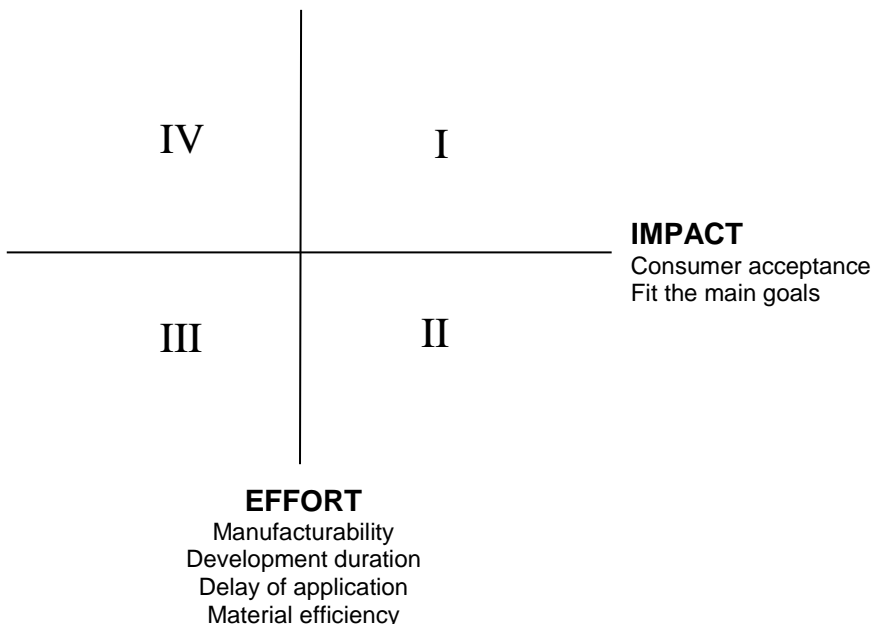


Figure 15. Impact-effort matrix (source : Ingle, 2003)

This idea selection tool is proposed by Ingle (2003), aims to help selecting the ideas based on the effort that is needed to be put into the idea in comparison to the impact it will give. The decision of where to locate a certain idea on the matrix is based on an open discussion with all the ideation session's participants.

Ideas laid in quadrant IV were put aside since it was considered as not impactful enough but yet needs a lot of effort to implement it. The ideas that laid in quadrant I and III were brought up into discussion, where they can be combined or modified so they could ‘move’ to quadrant II. The ideas that laid in quadrant II in the end were then proceed to further discussion on prototyping strategies.

3.5. Prototype and Test (loop)

According to Houde and Hill (1997), there are three kinds of prototypes namely Role, Look and Feel, and Implementation prototypes. The three of them are related as shown in the Figure 16 below;

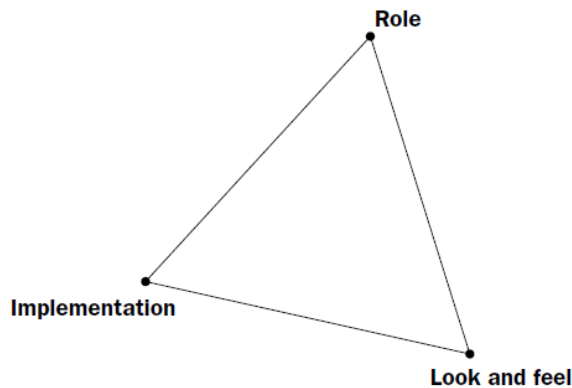


Figure 16. A model of what prototypes prototype (Houde and Hill, 1997)

Role prototype aims to address the question of how the solution can serve in the user’s life. Look and feel is related to the sensory perception of the solution. And implementation prototype imitates the performance of its functions (ibid. p.3).

Given the problem fields of this project (Chapter 4.3.4) the prototypes in this project include all aspects of the three different prototypes proposed in the literature (ibid.). But focus was put on the performance of the solution. In a way, it could be considered as an implementation prototype.

3.5.1. Manual Prototyping

Manual prototyping was carried out in the facility for product development in Flextrus AB. The prototype has two main parts, the bottom and top web. For both,

the moulds are needed, since the sealing tool provided in the laboratory is limited only to straight sealing, while this prototype will have a special sealing pattern. So, the process of prototyping started from three dimensional designs of these moulds, done with the CREO software.

3.5.1.1. Moulds Preparation

The bottom web's mould is 3D printed in Lund University's facility (Ingvar Kamprad Design Centre's ideas to prototype lab). It was measured to fit the prototyping equipment in the laboratory. The mould for bottom web has four different bubble shapes; therefore, four different sealing parts are needed.

The sealing parts were made in aluminium, CNC milled in the facility of Prototypverkstaden, Medicon Village, Lund. The four sealing parts were separately prepared for different shapes of bubble.



Figure 17 Mould for forming bottom web (left) and sealing tools (right)

3.5.1.2. Forming and Sealing

Forming of the bottom web (Nylon plastic) was done by using some different equipment in Flextrus AB's facility. First trial was done with Adolf Illig's KFG 37 vacuum-mould. This machine is working under a 1 bar vacuum pressure (when the pump is activated).

The machine has a heating compartment that is on a board that can be moved horizontally (slided) over the material, a mould that is placed on a mobile hand under the material, inside a vacuum chamber that can be activated manually. Firstly, the mould is located precisely inside the frame in the vacuum chamber. The material is placed at the frame above it and secured with a fastening lever. The heating part then positioned on top of the material for 10 seconds before the mould handle lever is pulled to move the mould closer to the material. When the mould almost touched the material, the vacuum pump is activated so that the suction force forms the material into the mould. The vacuum pump is activated for

10 seconds and after it was turned off, the mould's handle lever was released and the heater was removed. The bottom web can be removed from the frame by loosening the tighter.

Second trial was done with a blow moulding machine that is coded as FL005 in the laboratory (machine type not available). This machine has a higher working pressure (up to 4 bars).

This machine also consists of a frame for the material with a compartment to place the mould underneath it. The only difference is that this machine is working with high pressure instead of vacuum. Heating also lasted for 10 seconds and then the pump is activated so that the pressured air is blown on top of the material, to the direction of the mould, allowing it to be formed accordingly.

The sealing for the first two trials were done manually by heating the aluminium sealing tool with an iron. The material used for these trials was ONP film.

After the sealing tool was pre-heated for 10 seconds under an iron, it was then carefully placed on top of the formed bottom web. The iron then was also placed on top of the sealing tool and heating and pressing of the sealing part to the bottom web (manually done by pressing the iron with hand) were carried out for 15 seconds.

All durations were decided on trial and error basis, with basic know-how by the engineer on site (colleague in Flextrus AB) in performing a prototype building from such material.

3.5.2. Pilot Scale Prototyping

The next prototyping trial was done on a pilot scale in PackDesign's facility. PackDesign is a company working closely with food packaging, from machinery, service, accessories, until consultancy. During the period of this project, PackDesign had just repaired a Multivac[®] type R230 form-fill-seal machine with three cells (three bottom webs were formed in a row). Since the company is located just right next to Flextrus AB's manufacturing plant, it was very convenient to collaborate with PackDesign for upscaling the prototype.

One cell of the forming part was replaced with the mould of a triangular shaped mould with three different shapes of bubble on each corner. Three prototypes were made in this machine, with different materials and process conditions (more about this in Chapter 4).



Figure 18. Mould for forming (left) and sealing (right) on Multivac[®] machine

3.5.3. Qualitative Tests

The three prototypes (P1, P2, and P3) each has three different bubble shapes on it (A, B, and C) were then tested to see the performances. Both qualitative and quantitative tests were carried out.

3.5.3.1. Qualitative Tests

There were two different qualitative tests; scoring and popping test. The scoring test was done by handing out samples to colleagues in Flextrus AB with a scoring form to see the compatibility with the five main goals (see form in Appendix 3). This method is a modification of packaging scorecard (Olsnats and Dominic, 2003) that is suggested to evaluate the performance of a packaging solution for different actors in the supply chain. The scoring is based on subjective opinion of the respondents within a range from one to ten; given ten is the most satisfying score. Each main goal was weighed and these factors were multiplied with the scores given. The sum of scores was then translated to percentage values using the formula below;

$$\% \text{ compatibility} = \frac{[(\sum_{n=1}^5 k \times s) - 15]}{135} \times 100 \%$$

With $n = \text{number of main goals}$

$k = \text{multiplication factor for related main goal}$

$s = \text{score given for related main goal}$

The second quantitative test is a popping test. Twenty samples of each prototype were taken randomly from the batch and each bubble is popped by hand. The number of successful popping – defined as making a sound and break (a part of) the sealing around the bubble as it is popped – is recorded for each sample. This

test is adopted from the current tests done by PopPack LLC for the prototypes (Perell, 2016)

3.5.3.2. Quantitative Tests

Quantitative tests were carried out to see the mechanical performances of the samples. The data is taken in triplicate for each bubble on each prototype (total of 27 measurements) for both popping force and peel strength.

The first test is popping force measurement. This test was carried out with MultiTest 10-i by Mecmesin, available in AR Carton's facility (AR Packaging Group, Maskinvagen 1, Lund, Sweden). The equipment has a cylindrical probe with flat end that connected to a 100N cell. This probe and cell arrangement was moving down in the Y axis at a speed that was set from a program in the computer. The bubble sample was put on the platform located right under the probe. In this test, the speed is set at 100 mm/minute with total displacement (vertical distance travelled by the probe's flat end) of 13 mm. A data of load when break was recorded by the program; and the result was exported to a Microsoft Excel[®] file. This data shows the maximum load taken by the bubble before it popped.

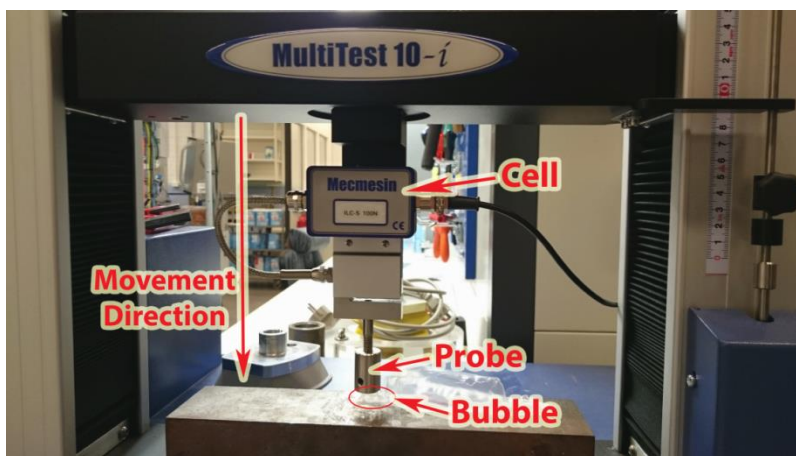


Figure 19. Equipment for measuring the popping force

Peel strength is another measurement done in this project. The test was conducted in Flextrus AB quality control's laboratory with INSTRON 3342J7592. This equipment has two clams positioned vertically. The bottom clam is static and the upper one is moving up in Y axis. The popped bubble from the popping test was separated until it reached the intersection sealing between the bubble and the product compartment. The two separated flaps are placed in the clams and held in

place with compressed air pinching. The upper clam is connected to a 50N cell and moving at 300 mm/minute. The peeling was set at a standard of 25 mm (distance travelled vertically) but during the experiment, it was stopped before the complete distance was travelled due to the limitation of the sample. The researcher did not do this test by herself, instead it was done by a quality control engineer in Flextrus AB due to the high risk because of the sensitivity of the machine.

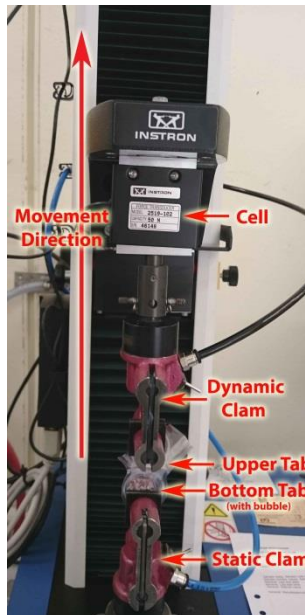


Figure 20. Equipment for measuring the peel strength

3.5.4. Improving the Best Performing Solution

A small iteration session was done in order to improve the best performing solution. The nature of this iteration is technical, and will be discussed later on in Chapter 4.5.7.

3.5.5. Pitching to Manufacturer

Pitching to the manufacturer was done on the 20th of April 2016, when Torben Noer, Packaging Development Manager, Global Cheese-NPD from Arla Foods Denmark came to the office of Flextrus AB. The researcher did a presentation and prototype showcase to them, emphasising the performance of iterated prototype.

Feedbacks from them were gathered regarding the feasibility of this solution and suggestion on further development.

4. Results and Discussion

This chapter provides the result and also discuss the output from the data collection part of this study. The challenges of the design thinking implementation in this project and critiques on this project are also discussed here.

4.1. Understand

The more understanding of the problem, the better starting point it is for the project. In relation to this, some literature studies were conducted, as well as some expert interviews. The results of these activities are mostly presented as the frame of reference of this project. The result that will be discussed here is from literature studies on ergonomic requirements.

Ergonomic design ensures an improved usability and accessibility of the product (Silva, *et al.*, 2012). In the field of food packaging, ergonomic designs had been taken into consideration by several studies (e.g. Silva, *et.al.*, 2012; Forsman, *et al.*, 2012; Dahlberg, *et al.*, 2003), showing the importance of this for this project.

The focus of ergonomic requirements in this project is the different kinds of grips. Since the user group is defined as elderly people, it is assumed that this group has low strength and even lower precision (due to arthritis or vision impair). With this approach, it is possible to assess how large the tabs should be in order to allow a convenient grip. Figure 21 shows different kind of grips along with the strength and precision provided by each grip.

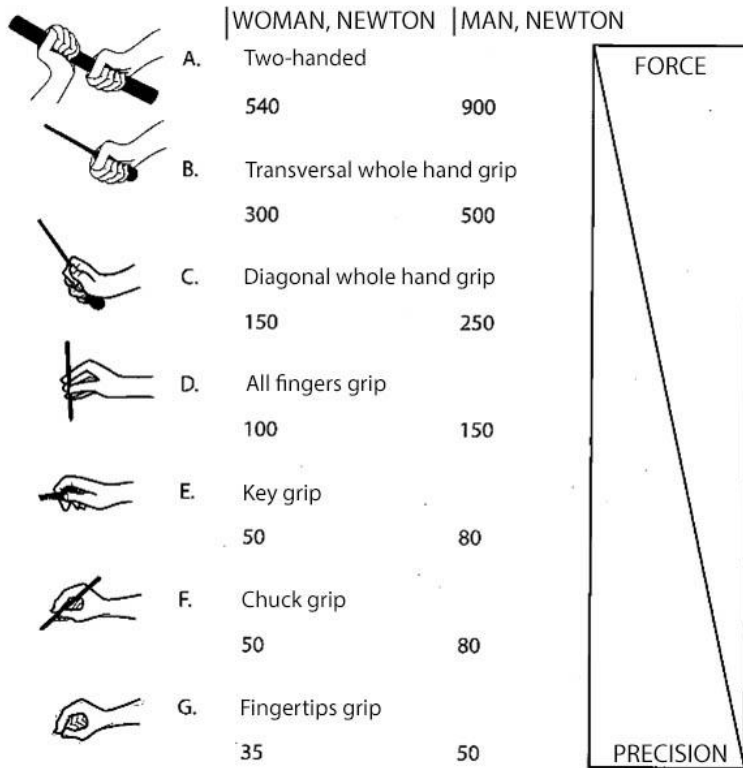


Figure 21. Different kind of grips with precision and force difference (Bohgard, 2015)

Through discussion with the project’s team, the current packaging allows the grip type G due to the narrow opening tabs. This condition is considered not optimal since the fingertip grip only provides a really low force. The ideal grip that is desired to be allowed in the final solution is the key grip (type E) or the all fingers grip (type D) in which will provide high strength even the precision is lower than the current packaging. This is why it is desired to have a solution that requires lower precision to open it.

4.2. Observe

Adapting the framework of needfinding (Patnaik and Becker, 1999) and suggestions from ISO 17480:2015 on Ease of Opening, the consumer tests were conducted and results as follows.

4.2.1. Consumer Test: Survey

The survey was carried out by giving the consumer a Herrgård cheese from one of the three brands available (Arla, Skånemejerier, and ICA). These are not the only brands available in the market, but they are considered as the most commonly found in grocery stores. Arla and Skånemejerier are the two biggest players in Swedish cheese market (MarketLine, 2014), while ICA is a private label of one of the biggest retail chains in Sweden. Panelists were directed to answer the questions on the questionnaire based on the specific product that they got. Table 6 shows the results of this questionnaire.

Table 6. Consumer Behaviour towards Commercially Available Cheese

Aspect/Brand	Arla	ICA	Skånemejerier	Notes
Product familiarity	6.55 ± 0.60	5.24 ± 2.70	5.84 ± 1.52	0-7: not at all familiar – very familiar
Purchase frequency	3.75 ± 0.75	4.45 ± 1.51	4.00 ± 1.15	3: once a week 4: twice a month 5: once a month 6: less than once a month
Wastage Rate*	1.41 ± 2.26	1.40 ± 1.58	1.30 ± 2.53	0-7: never – often
Current Packaging Satisfaction	3.75 ± 1.14	3.55 ± 1.31	3.71 ± 1.25	1: don't like it at all 2: don't like it 3: neither like nor dislike it 4: like it 5: like it very much

* Standard deviation is higher than average, not enough sample population

As shown above, the product familiarity of Arla brand is the highest among the three, which is coherent with the report by MarketLine (2014) that Arla holds the biggest market in cheese products in Sweden. ICA private labelled product has the lowest result in this category, therefore the lowest purchase frequency as well. Which in this sense is intuitive, since the consumer will strive to buy something that they are more familiar with than not. The product wastage rate is not conclusive. Overall, consumer somehow likes the current packaging but yet they still have some struggle with opening it.

4.2.2. Consumer Test: Observation

In this part of the test, interaction between consumer, current cheese packaging, and Prototype 0 was recorded. Commentaries on each sample are also gathered.

4.2.2.1. Current Cheese Packaging

From the interaction between consumer and current cheese packaging, some important insights were aimed to be gathered. They are shown in the Table 7 below.

Table 7. Important Discoveries and Occurrence (n = 30 panelists)

Discovery	Occurrence (times)
Did not remove the lid completely	22
Started consumption from the sharp end	22
Could not separate the tabs	5
Opened from the sharp end (without “Open Here” sign)	3

The first observation was whether or not the consumer removes the lid completely. Removing the lid completely means there is a small chance that the re-closable feature can be applied. In other hand, if the consumer did not remove the lid completely, that might indicate the desire of having a re-closable feature on the packaging. This assumption is also supported by some panelists that commented on how they would like the packaging to be re-closable.

Starting consumption from the sharp end happened to be the common method to slice the cheese in this panelist group. Knowing where the majority of people started the consumption from, gives this project some insight on how to locate the bubble (the “Open Here” site).

Some panelists had a hard time separating the flaps at the beginning. From a technological point of view, it could be possible because of the heat that occurs due to the friction between knife and packaging material, melted the material around the “Open Here” tab a little bit, so that the two parts were attached to each other. This situation is expected to be solved by the separation of the flaps occurred when the PopPack[®] bubble bursts.

Some panelists did not open the packaging from the corners with “Open Here” sign. Instead, they opened it from the sharp end. This discovery shows that some (c.a. 10%) of the consumers did not follow the suggestion given by the “Open Here” signs. This could be an intuitive decision, because all three of the panelists that opened the packaging from the sharp end, started the consumption from the sharp end as well.

These discoveries gave some important insights to include in the next steps of the project, especially designing the packaging solution.

The three brands were packed in a similar way. Difference only occurs on the lid material and graphical designs. This explains why there are not so much difference between the three brands. But overall, the current packaging served a score of slightly below 4 on the satisfaction scale used. This means that the consumers are somewhat satisfied with the current packaging since they like it to some extent.

4.2.2.2. *Prototype Zero*

Prototype 0 is a preliminary prototype provided by PopPack LLC. It consists of one bubble compartment with an empty product chamber. To reduce confusion for panelist, a sticker written “OST” (cheese in Swedish language) is attached to the upper surface of the product chamber. Figure 22 below shows the time of opening by the panelist, including the gender.

	First sample (sec)	Second sample (sec)
Total	54.73 + 43.39	19.70 + 11.69
Male	47.93 + 32.80	19.87 + 11.51
Female	61.53 + 52.20	19.53 + 12.26

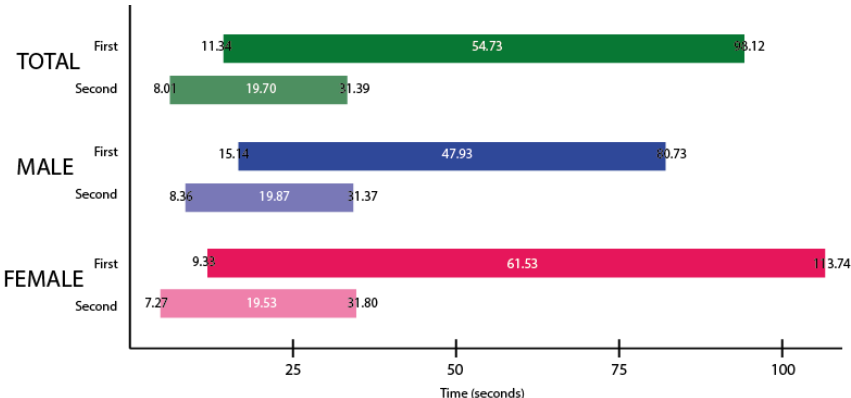


Figure 22. Time needed to open Prototype 0 samples by different genders of panelists

As shown in the Figure 22 above, the opening of first sample takes longer time. This is partially because the sample is unfamiliar so the panelist needs to study the opening instruction given on a separate piece of paper first. But once the instruction is comprehended, it took much faster to open the second sample. This is showing that the Prototype 0 did not really provide an intuitive opening. However, all of the results are overlapping on the graph, meaning that it could not be said that there is a significant difference between different genders.

Satisfaction of Prototype 0 is equal to 3.40 ± 1.22 (detailed results on Appendix 4). This means that the range of answers fall between 2.18 to 4.62 points. Two points mean that the panelist don't like the Prototype 0, three for neither like nor dislike, four for like, and five for liking the prototype very much. From the comments collected in the questionnaire, a lot of consumers still found it hard to separate the tab even after popping the bubble. It was difficult to understand the idea at the beginning but after opening the first sample, consumer could see the potential of how this solution might work, that is why some consumers mentioned that they enjoyed their experience with this popping solution. With an average of 3.40 points, it is still really close to the neutral reaction from consumers (neither like nor dislike). Understanding what is expected from a packaging solution will be a good way to push this number to a higher end.

Also in this observation test a small interview was carried out about what is expected from the consumers to be included as good popping criteria.

4.3. Point of View

This stage of DT process involves list generations out of the data collected from the *Understand* and *Observe* stages.

4.3.1. Consumer Journey Map

A mapping of consumer's journey and the interaction with cheese packaging gathered from the previous stages was done and visualised as shown in Figure 23.

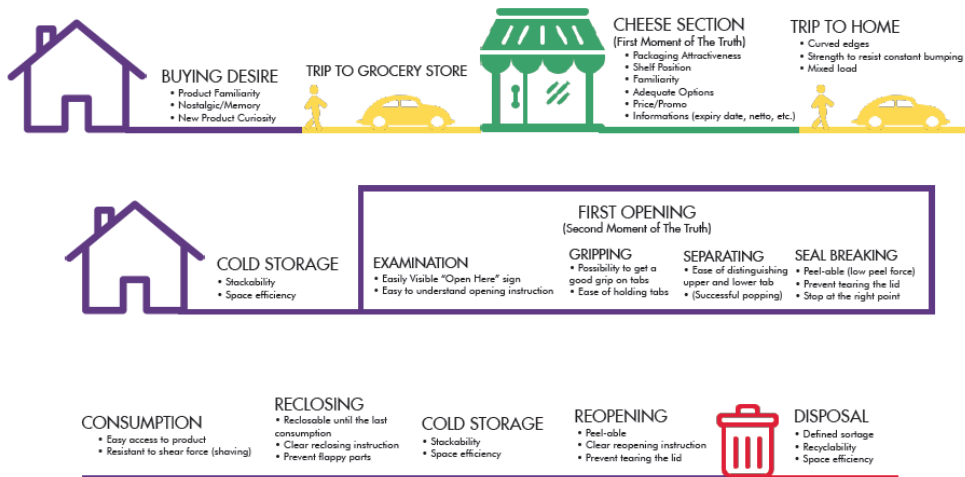



Figure 23. Consumer journey map

4.3.2. Persona

A simple persona was generated to empathise the needs of the user group selected. This persona was also presented at the beginning of the brainstorming session to give the audience better understanding about the ‘people we are helping’.



Source : <http://www.clickhole.com/article/6-elderly-couples-share-their-secrets-long-happy-m-2268>

Mr. (83) and Mrs. (78) Leinster are going to celebrate their golden wedding anniversary soon. They live in a small lovely house in the countryside. Their grandchildren come visiting every month when they have big-Sunday-brunch with grandpa's special treat; spinach quiche. On daily basis, this couple hang out with their neighbors, get some works done in the backyard where they grow fruits, and take a walk in the park in the afternoon with their dog. They do grocery shopping every Wednesday, just after their book club meetup.

Products they like: ✓ Healthy ✓ Flexible ✓ High dexterity ✓ Smaller portions ✓ Shelf stable

Figure 24. Persona of user group

4.3.3. Successful Popping Criteria

During the observation test on Prototype 0, a small, unstructured interview was carried out to gather desires from the consumers towards the bubble itself. The findings are summarised into points as follow;

- *Good popping sound*
During the observation test, some panelists were a little bit scared when the popping made a loud sound. As a standard, the good popping sound is compared to the popping sound occurred from bubble wrap popping. It has to still make a noise, but in a way, it is expected not to be too loud.
- *Easy to open function*
The aim of adding the bubble to the packaging is to make it easier to open. This is why a successful popping should break the seal or material at the right place so this function can be fulfilled.
- *Doable with one hand*
The bubble should be easy enough to be popped with one hand. The size should be adjusted so that it is within the range of thumb and index finger expansion.
- *Minimum energy*
It has to be soft enough and at the same time strong as well to resist the logistical processes.
- *Easy to understand concept*
Since the findings from observation of opening Prototype 0 shows that the sample is not intuitively possible to open, the packaging solution should be able to get the concept across clearly to the consumer so that it is not necessary to study the opening instruction so closely before opening it.

4.3.4. Problem Fields

From the lists generated as discussed in the previous sub-chapter, the problem fields of this project were defined through discussion between researcher and team members from Flextrus AB. These fields built the brainstorming questions on the next stage. They are listed as follow;

- Easy to open function (popping)
- Good popping sound
- Low peel force
- Attractiveness (fun shape, aesthetic standpoints)

- Easy to understand concepts

These five main goals are the brainstorming questions in the ideation session and will later on be the scoring criteria for the preliminary tests of the prototype to decide the winning idea.

4.4. Ideation

The ideation session was started with a brainstorming and sharing session, clustering, scoring, and then mapping the idea on an impact-effort matrix.

4.4.1. Brainstorming

As mentioned in the methodology, the brainstorming session was divided into two parts; brain dump and discussion. In the first session, the instruction given was just to write down all the ideas related to the PopPack[®] technology on cheese packaging. Some of the participants of the session had been in touch with the project, mostly as interviewees.

After brain dump session, the ideas are shared to the floor and posted on the wall (ideas were written on sticky notes). The next step is discussion, or also called as the idea generation. The five problems mentioned in the problem fields (Chapter 4.3.4) are formed into how-to questions and launched one by one as a brainstorming question. The questions are as follows;

- How to assure easy to open function through popping?
- How to get a good popping sound?
- How to achieve low peel force?
- How to make the solution attractive?
- How to make it easy to understand concepts?

Total ideas gathered from the brain dump and brainstorming session are more than 80 ideas.

4.4.2. Clustering

The ideas generated in the brainstorming session were then mapped according to their affinity to one another, forming different clusters/groups of ideas. Six clusters were made, they are:

- Commercial and widgets inside bubble
- Graphical designs
- Bubble designs
- Bubble position
- Materials
- Sealing/Peel

After the ideas are clustered, idea selection was carried out, and then the best ideas proceeded to the next step. Only ideas in bubble designs group was scored because this cluster was voted as the group with the most urgency, so this project will continue look into that. The rest of the ideas are kept by the company (confidential) for the further development purposes.

4.4.3. Mapping

Ideas with highest scores are mapped on the impact-effort matrix. Positioning of these top scored ideas on the map was based on open discussion. Some further discussion included adjustments and combinations were done for ideas that were considered as low in input but also low in output (easy to apply but not really interesting for the consumer) and high input and high output (how to make the idea easier to apply since it will potentially attract consumer) so that these ideas can move to the quadrant II with low input and high output.

In the end of this session, four bubbles shape alternatives laid in the quadrant II, along with utilisation of material with laser perforation material, sealing angle and size, and some business strategy suggestions. For the continuation of this project, bubble shapes were emphasised and also the utilisation of material with laser perforation for the lid.

4.4.4. Bubble Designs

The four bubble designs from the brainstorming session are illustrated in the Figure 25 below.

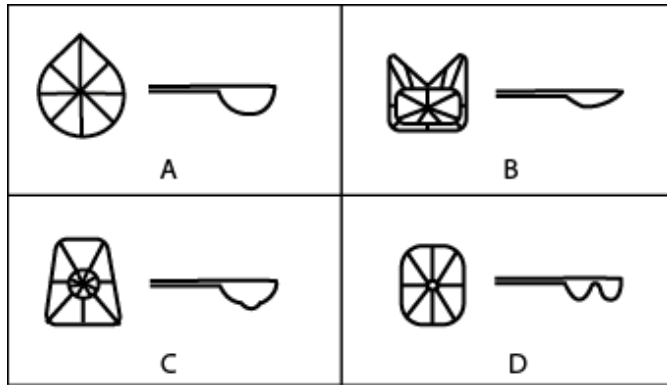


Figure 25 Bubble designs from ideation session (*left: top view; right: side view*)

Bubble A

The round bubble gives the idea of a button so it gives an idea to the consumer that it has to be pushed, intuitively. The little channel directed to the upper part of the bubble is expected to intensify the pressure when the bubble is burst so it gives more impact on the seal breaking.

Bubble B

Shaped like an M at a glimpse, this bubble is intended to also concentrate the air into direction of the upper side of the bubble. The little channels are shaped in a decreased angle so that it may give a higher pressure to break the seal or material above it.

Bubble C

The trapezoid shape of the bubble is dedicated to give a good direction for the gas movement inside the bubble so that when it is burst, it breaks the seal or material on top of the bubble. The little bump is intended to give a more intuitive opening, since it will give a tactile feeling as a button.

Bubble D

The little hump in the inside of the bubble is intended to act as a ‘jack’ to separate the upper lid material on the tab further from the bottom one.

4.5. Prototype and Test (loop)

This project ended with a loop of prototype-test-prototype-test. This iterative process was not adequate for a DT project evolves through this loop (or even other loops) several times before the artefact is deemed good enough as a solution.

4.5.1. Manual Prototyping

Trials were done in the prototyping laboratory in Flextrus AB's facility. Both vacuum and blow moulding machines were used to form the base web and sealing was done manually by heating the sealing piece with laundry iron.

First try was carried out in the vacuum moulding machine. This trial was not working because the bottom web was failed to be formed. After discussion with different staffs in the office, it was suspected that the maximum vacuum pressure of 1 bar provided from the machine is not strong enough to form the nylon plastic. Therefore, the next trial was carried out in the blow moulding machine.

The maximum pressure provided by the blow moulding machine is 4 bars. With this mould, the bottom web could successfully be formed though with defect. But it was decided to proceed with the bottom web as the bubble compartment – which is considered as the main part of this project – is formed perfectly, while the defects just occurred in the product's compartment.

The bottom webs formed were then sealed. Three different films were tried, to get the one with the best peel. As the sealing is a crucial part of the prototype, it was necessary to make it as good as possible. Unfortunately, the manual sealing method was not suitable for the prototype. There are three important variables to be controlled in sealing process; the time, temperature, and pressure. The iron used has no thermostat to maintain the temperature stable. The time and pressure were controlled to some extent, by using weight on top of the iron in order to provide constant pressure. However, different temperature across the heating plate, unequal pressure applied across the sealing part, makes it impossible to modify the variables and get an optimum operation conditions. Almost all of the sealing was either burnt or unsealed.

4.5.2. Pilot Scale Prototyping

After several discussions and rounds of trial and error, it was decided to continue the making of the prototype on the pilot scale. One of the bubble designs - Bubble D - and the bump on Bubble C were eliminated. Both these decision were the compromises had to be made due to the machine limitations to form a small angle. According to the interview (Kalitta, 2016), to create such angle, a stamper is needed, while this part is not provided by the machine used for prototyping. It was decided to change the triangle to imitate the shape of the current cheese packaging and also to provide space for the different bubble designs on each corner.

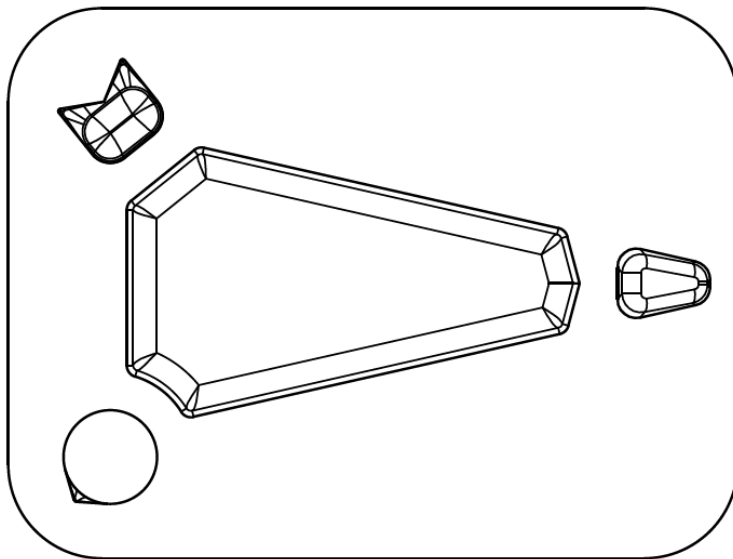


Figure 26. Forming part

Shown in the Figure 26 is the design of the mould used for forming the bottom web. Each bubble designs affected the shape of the product compartment in different ways. The intersection between bubble and product compartment is an important part since it will affect the peel force needed to open the package and access the product.

4.5.3. Prototypes

Three different prototypes were made in this project. They were coded Prototype 1 (P1), Prototype 2 (P2), and Prototype 3 (P3). All three prototypes have the same

bottom web, while the top webs were varied. Table 8 below shows the material and process conditions for the prototypes.

Table 8. Prototypes and Conditions

Prototype Code	Bottom Web	Top Web
P1	Nylon 70/100 Forming 5.8 seconds at 105°C, 6.5 bars	Ecobar 12/40 AF Peel Sealing 2 seconds at 120°C, 3 bars
P2		OPET/PEP Peel Sealing 2 seconds at 115°C, 3 bars
P3		OPET/PEP Peel Sealing 2.5 seconds at 120°C, 1.5 bars

The process conditions were decided through trial and error on site, supported with pre-existing knowledge of material properties from the engineers in Flextrus AB. The material for the bottom web was chosen since it is the same material as used for the current cheese packaging. Different top webs were to give different peels on the final solution.

As mentioned before, each prototype has different bubbles on each corner. Figure 27 shows the prototypes made in this project.



Figure 27. (from left to right) P1, P2, and P3

The prototypes were produced in a square form as shown in the Figure 27 for P3. They were manually cut according to the shape of the bubbles so the final prototype looks like P1 and P2 on Figure 27.

In most of the samples, Bubble C has been burnt around the sealing. Adjustments made on the process conditions was not quite successfully solved this problem. In some samples, the Bubble C was not formed on the bottom web; it was suspected that this happened due to the overheating of the form and failure of the cooling down system on the machine.

4.5.4. Qualitative Test

A scoring test with fifteen respondents from different business divisions in Flextrus AB was carried out as a qualitative test, along with a popping test, where twenty bubbles from each sample were popped.

The scoring test gave the result on compatibility of each bubble with the defined main goals at the earlier phase of this project. The main goals were ranked according to its importance to the functionality of the bubble as shown in Table 9 below.

Table 9. Weight of Main Goals

Criteria	Weight
Easy to open through popping	5
Low peel force	4
Easy to understand concept	3
Good popping sound	2
Attractiveness	1

Respondents were asked to give a score ranging from one to ten, given ten is the best fit on their satisfaction. The given scores were then multiplied with the weight of each main goals. The results were then translated to the percentage of compatibility with main goals as shown in Figure 28.

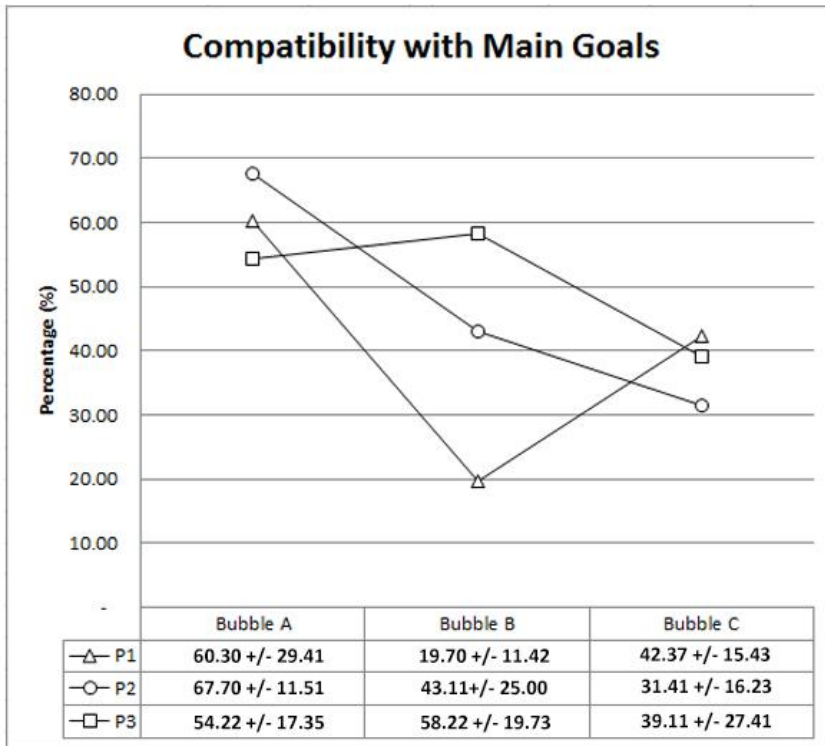


Figure 28 Results on scoring test

Among all of the prototypes, P2 Bubble A performed the best in this test. Comments collected from the respondents said that they still could not get good enough tabs separation even after popping the bubble. Bubble A also performed the in comparison to Bubble B and C on P1 and P3 in regards to their compatibilities with main goals.

The second qualitative test is the popping test, which results were shown on Figure 29 below.

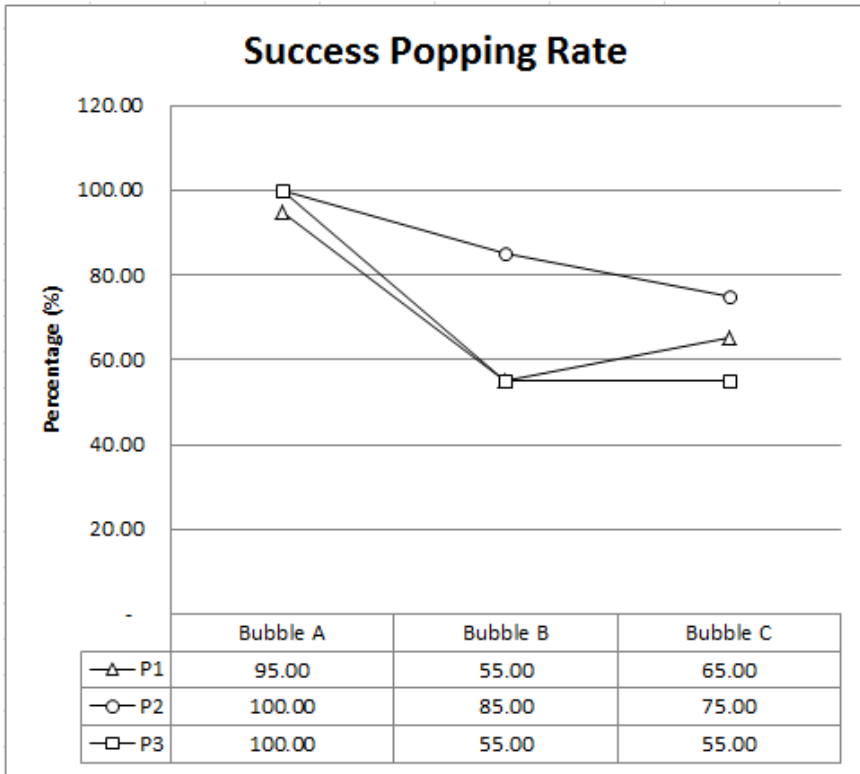


Figure 29. Results on popping test

A popping was deemed as success when it made a popping sound. Bubble A performed the best on this test, showing excellent result of 100% for both P2 and P3. P2 also gave the best results across different bubble designs.

From the qualitative tests, it could be foreseen that Bubble A on P2 has the highest potential to be the winning idea.

4.5.5. Quantitative Tests

Quantitative tests were carried out in laboratory facilities in both Flextrus AB and AR carton (also a member of AR Packaging group). Using the equipment available, the force needed to pop the bubble as well as the peel strength needed to break the seal between bubble and product compartments were measured.

The popping force is an important parameter since it will define how easy the bubble feature to be used. Results on this test are shown in Figure 30 below.

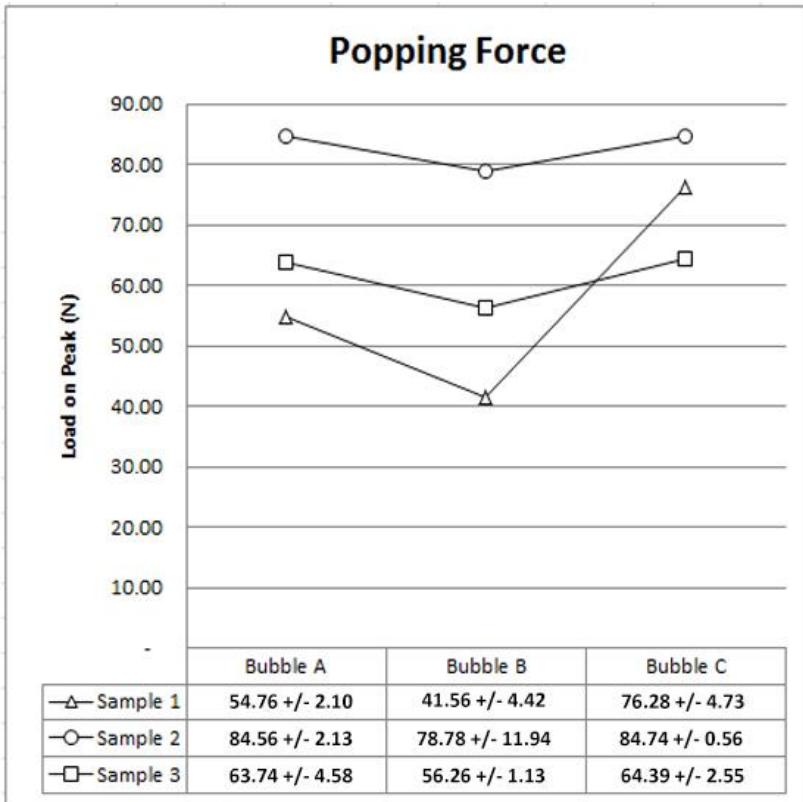


Figure 30. Results on popping force measurement

The lowest force needed based on this test is to pop the Bubble B, across P1, P2, and P3. The highest force is needed to pop Bubble C on all prototypes. It is not defined yet how high should the required popping force be. It has to be low enough so it is not too hard to pop it, but also high enough in order to resist through the logistical processes. It is considered necessary in further studies to look further on this matter so that the solution can perform perfectly in resisting the logistical processes as well as providing ease of usage.

In comparison with the literature (Bohgard, 2011), a force up to 50N (for women) and 80N (for men) is provided for the key grip, the grip that will be most likely used by consumer in order to pop the bubble. ISO 17480:2015 on easy opening mentioned that the force needed to open a packaging solution might not be the ultimate concern. Deemed to be more important is the dexterity of the packaging. As for this case, popping the bubble can be done by putting the bubble compartment against a table and press it with the palm of the hand, which will give higher force than any kind of grip.

As explained before, the bubble designs affect the intersectional shape between the bubble and product compartment. This will affect the peeling force needed to actually peel the top web and get access to the product.

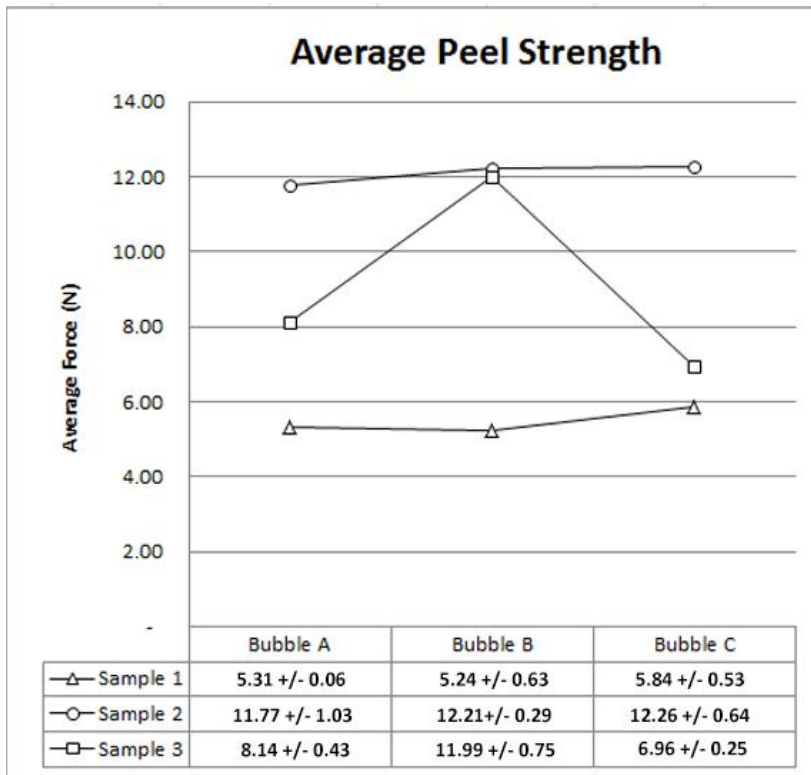


Figure 31. Results on peel strength measurements

Shown on Figure 31 is the force needed to break the sealing between bubble and product compartment. P2 requires the most force in comparison to P1 and P3 for all the bubble designs. Across the bubble, both P1 and P2 do not show a fluctuation as seen on P3. Through discussion with quality specialist from Flextrus AB (Arnfors, 2016), P3 has a lot of burnt sealing around the sample, which makes it hard to separate top and bottom web as it will be the tearing through the material instead of breaking the sealing. This is why the fluctuation on results for P3 is occurred.

Arnfors also stated that the peel strength is highly dependent on the material combinations as well as the thickness of the sealing. This explains the rather flat graphs shown for P1 and P2. The bubble design affects the thickness of the sealing but not to a significant extent. Desired peel strength of a packaging solution is also

defined by the size of the product. For the product as big as the block cheese, a range of 8 to 15 Newton is considered ideal.

The quantitative test is a good approach to see the technical performances of the samples. It is quite inconclusive which is the best solution based on these tests, since there are a lot of external factor to consider more than just the numbers coming out from the tests.

4.5.6. Best Performing Solution

Based on the performances of the samples in different tests and set of discussions carried out between the researcher and colleagues in Flextrus AB, P2 Bubble A has the highest potential to be the winning idea. Performed very well on qualitative tests and still fit into the preliminary limits set on the quantitative tests, P2 Bubble A could be developed further to make it even better.

4.5.7. Improving The Best Performing Solution

A simple iteration was carried out to improve the P2 Bubble A. The problem found across the different tests on this sample is that it does not perform consistently in regards to which part of the bubble it bursts when popped. This made the purpose of this iteration phase, to weaken the sealing on a certain part of the bubble so the air is directed to that way and break the seal on the desired place.

The idea was to mount the rubber plate - a part in the sealing zone on the machine - in certain areas so that they have tighter sealing due to the higher pressure on that zone. The mounting was done with an attachable Teflon sheet as shown in the Figure 32.

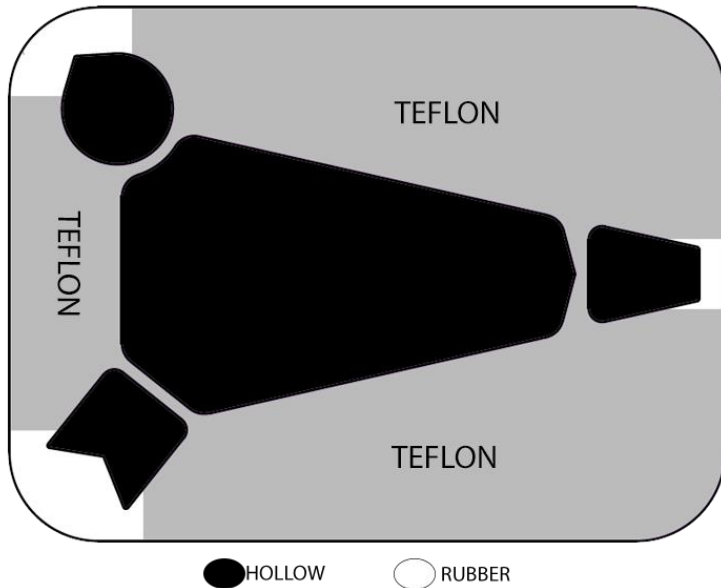


Figure 32. Modification on rubber plate

This modification is expected to give the areas without Teflon to have weaker seal, therefore the air from the bubble will tend to break that seal on when popped. There were no comprehensive tests carried out for this iterated prototype. To see if the attempt was working, a small popping test was carried out, and the result was quite satisfying to some extent.

4.5.8. Pitching to Cheese Producer

The final part of this thesis project is to pitch the idea to potential client. In this case, a presentation of the project was done to Arla Foods, Denmark. Some important feedbacks on feasibility of implementing this idea were gathered.

First is the position of the bubble. The winning idea is the Bubble A that is positioned in the upper corner of the packaging, but the packaging line in the cheese factory will not be able to do such cutting, since the knives are working on a straight line along the packaging. Suggestion was to position the bubble on the Bubble C location.

It is also desired that the popping will burst the whole circumference of the bubble and separate the tabs in a more extreme manner. This has always been the goal of Flextrus AB as well, but as in this early development phase, bursting the sealing on a certain part is the furthest point deemed possible.

For launching purposes, it is suggested to launch this new packaging solution on a new product. This is based on the cost that needs to be invested on educating consumers about how to open the packaging with bubble compartment. A campaign or commercial on electronic media is expected here. Launching it together with a new product will be a reasonable way of investment.

4.6. Critiques on This Project

Implementation of a new technology in a new market is always challenging. Especially when there is no other market that has this technology commercially available yet. Benchmarking is not something that could possibly be done. Therefore, the output of this thesis is more relevant for further exploration and development purposes rather than for commercial purposes. Some measures were taken to make this development process in line with ISO 17480:2015 with expectation that the final solution will be readily able to have the easy to open claim.

The best result stated in this project – as discussed earlier – might not be absolute, since there is no valid nominal force standard. The estimation done in this report might be adequate, but more exploration including some experts from engineering as well as medical fields might help the final solution to be more robust.

From manufacturing point of view, there will be parts need to be changed on the packaging machines due to implementation of this solution. First is the moulding part. The cheese packaging is a potential product in which the PopPack® idea can be implemented on, since the bubble can be formed together with the bottom web on the fill-form-seal machine. This requires a change of mould on the forming part of the machine. The new mould will have the bubble shape on it. For machine with stamper (as it is in some products), the shape of this part should be changed too. The sealing part will also be affected. Both the sealing metal and the rubber plate should be changed to accommodate some space for the bubble as well as forming the seal around the bubble.

From logistics point of view, the location of the bubble will be the deal breaker. So far, it is assumed that it will be located in the sharp end of the packaging as suggested by the manufacturer, it will give only a small impact on the reel size (approximately 100 mm wider, see Figure 33). When stacked on a layer of two

layers, then the height of the reels stacked on pallet will be 200 mm taller. Since the shipment of palette was done by a third party company, researcher could not get adequate information on the measurement of the container. So this 200 mm change of pallet height might or might not be manageable.

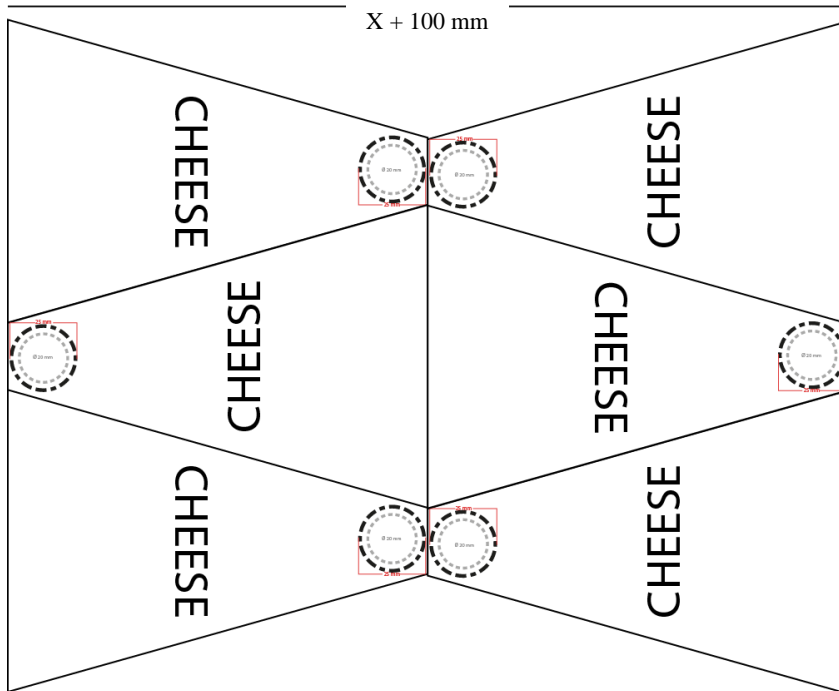


Figure 33. Illustration of cheese packaging on reel with bubble (top web)

Research about cheese packaging specifically is not quite commonly found. Limited background information is also a challenge in this project, but it is somehow manageable by interviews with experts in Flextrus AB.

There was a discussion to conduct another consumer test in the end of this project, since there was a possibility to get same crowd (panelists from AR Packaging pension-meetup) so it might be possible to see if there was any change of satisfaction. In the end, it was decided not to do this because the prototype is not quite robust (misaligned sealing, unformed bubble) yet. Based on project management consideration, it is not a good time to invest more resources to conduct such a big consumer test yet. This could also be considered as a weakness of this work, because the nature of the project is consumer oriented, but yet it could not be proven to what extent had the development improved consumer experience.

However, this is justified as a nature of exploratory study. Flextrus AB has a team to explore further on the application of this technology for cheese, other food products, and also healthcare products. This study is an initial step with limited scope for block cheese product, but the methods and approaches can definitely be used for further developments.

4.7. Challenges and Learnings from Design Thinking Implementation

As suggested in literature (e.g. Brown, 2008; Schweitzer, *et al.*, 2015; Kolko, 2015) a DT project team ideally consists of people with different backgrounds. In this project, the researcher (pursuing a Master of Science degree in Food Innovation and Product Design) worked closely with product development engineer and business strategy manager of Flextrus AB. To generate more ideas through the brainstorming session, participants are from different field of expertise (e.g. product manager, technical/engineering manager, and machinery provider).

Challenging as already warned in the literature (Kolko, 2015), the researcher also faced some challenges in this ideation stage. Communication was fairly good on floor, but during the silent brainstorming in pairs, it was not the same case. Collaborating the ideas and perspectives from two completely different expertise fields were not smoothly done. Sometimes some specific terms were used and they hindered the partner to understand the idea.

The whole idea of DT was also new for some participants, and not everyone had ever had the opportunity to work closely with innovation specifically. This was also a challenge to introduce the main idea of the session without being inefficient due to limited time and multiple brainstorming questions in this session.

The most challenging part according to the researcher is the ideation part. Selecting different tools that are efficient but also easy to explain to the participants that are not familiar with such session was one of the biggest challenges. Being a moderator in an ideation session was also challenging. Being firm and stricter with the rules was necessary

As for the implementation of DT in general, researcher got a lot of help from colleagues in Flextrus AB and also understanding that the project is not the same

with development project methods the company is familiar with. The project management was seemed unclear in some stages, in comparison to the conventional development projects, especially given the strict timeframe for the master thesis project. But thanks to understanding and helps from the company, even when some tasks had to be carried out under a very short notice, they were still all conducted well.

DT is a good approach for such project because of the exploratory phase of it contains a lot of opportunities to be explored. It might seem hard at some stages, especially when the team members have other tasks to do aside from only this project, but the data collected in this project is highly appreciated and potentially be useful for further development of this technology by the company.

5. Conclusion and Suggestion for Further Researches

This project started with background research on the consumer behaviour in the cheese market. The research questions were derived from this research. In this chapter, those questions are answered. The researcher also gives suggestions for further research to be conducted by the company, as well as other researcher willing to implement design thinking in food packaging development.

5.1 Conclusion

The PopPack® solution can **potentially be a solution** to answer the market needs on **easy to open packaging** with the round bubble shape (bubble A in this project) positioned in the sharp end of the packaging (location of bubble C in this project) with the base web from Nylon 70/100 and OPET/PEP Peel as the top web. This sample performed the best through most of the qualitative tests. For the quantitative tests, it showed values around the desired ranges, but still, this range is only an assumption.

- *What is the best way to implement PopPack® technology on block cheese packaging?*

Some adjustments need to be made of course upon the implementation of this technology. This project had shown the best bubble shape based on the tests carried out during the process as well as what are the properties to be kept and changed from the current cheese packaging. Changes in the packaging line on the cheese manufacturer site is also anticipated, therefore the development has to be mature enough before it is implemented.

- *How applicable is DT approach in development of food packaging?*

For a project on the early development phase like this, DT may ensure the comprehensiveness of the solution in addressing the consumer demands. For example, in the ideation stage, some ideas for the engineering and even business strategies were generated. Meaning that it broadens the scope of issues this solution can answer and possibly succeed in the market. Even though it was challenging in some parts, DT is still deemed as a good approach for this kind of project.

5.2. Recommendations for Further Development

From the consumer studies, it is recognised that there was a need from the market on re-closable packaging. Trying this bubble feature on a re-closable material could be interesting so that the final solution can address two demands from consumers, easy to open and re-closable. Also to be tried is the soft tray packaging, as for sliced cheese. This kind of packaging also uses the form-fill-seal technology, so it is feasible to form the bubble in the packaging line.

In line with the feedback given by the representatives from Arla Foods, that the most possible way is to put the bubble in the position of Bubble C on the prototype. So, it is highly suggested that future studies will explore more about this position, since the angle is smaller so it might impact the peel strength needed. An investigation to the manufacturing plant also deemed necessary in order to see the flexibility available on the packaging line. The size of the reel holder, cutting area, and conveyors in general, will determine the possibility to integrate the bubble on the packaging, size wise.

5.3. Suggestion for Further Research

“Design thinking is driven by intelligence that embraces innovation and gives your organisation the freedom to explore multiple ways to solve problems – and discover the option that best delivers competitive advantage.” (Clark and Smith, 2008).

Application of DT in food packaging innovation may result on a solution that can answer consumer demands. As food packaging has been recognised as an important aspect that can encourage purchase of food product, having the

consumer in mind during the development process – as suggested by DT approach – is very important.

The collaboration between researcher and industrial supervisors in this project went smoothly, made the team was efficiently working. Open-mindedness was really important here, as well as willingness to learn from each other. For cases where the partners are not familiar DT, a session or two about DT might be necessary, or maybe a small trial project can be conducted so the partners have hands-on experience on using DT tools and changing from one thinking mode to another.

It is interesting to see how the solution can be perceived by the consumer. It is highly recommended for the further research to conduct another consumer study, to make sure that the problem fields established in this study successfully address the needs from the consumers or not. It is suggested to fill the prototype with actual product to avoid confusion that occurred in the consumer study of this project; when the consumers tried to pop the product compartment instead of only the bubble. Some graphic designs might also be applied on the prototype to show which side is up.

Educating the consumer might be done in several ways, and commercial campaign might be a way to do so. During the brainstorming session, this has been discussed (detailed results for this cluster of ideas belongs to the company, Flextrus AB). For further consumer study, a video showing how the packaging can be opened might be used. Imitating the commercial that will probably be used to market the final solution can be useful to ensure that the commercial is adequate and necessary to introduce the product, before a bigger investment of making and publishing the commercials is done.

For the nominal forces needed to pop and peel the packaging, a further study can be focused on establishing the desirable range of forces needed. As explained before, the bubble should be easily popped and sustain the bumping during the logistical process at the same time, meaning too low popping force is not desirable for the logistical process, but too high force is not desirable for the consumer. The desired peel strength is depending on the size of the packaging – according to the expert interview done in this project – a market study can also prove this point in order to establish the desired range.

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Expert interviews

Anderberg, J., 2016. Technical Product Manager, Flextrus AB, Lund, Sweden

Arnfors, H., 2016. Laboratory Engineer, Flextrus AB, Lund, Sweden

Bergin, M., 2016. Internal Sales, Flextrus AB, Lund, Sweden

Harrison, C. E. 2016. Marketing Director, PopPack LLC, California, USA

Kalitta, R. 2016. Owner, Packdesign AB, Lund, Sweden

Micevski, B., 2016. External Technical Service, Flextrus AB, Lund, Sweden

Perell, W. S. 2016. Managing Member, PopPack LLC, California, USA

Appendix 1. Questionnaire for Consumer Test

English version



ADULT CONSENT FORM	
Day/Date	Wednesday/ 10th February 2016
Venue	AR Packaging Senior Meetup, Lund, Sweden
Lead Researcher	Santika K. Chenderasa



Development of New Opening and Reclosing Features on Block Cheese Product

This research is being carried out as a part of Master Thesis Project. You will be asked to carry out a consumer experience test to and answer a few questions. A total of 30 volunteers will be asked to use these products. Further instructions will be given before starting the test. The test requires usually 10 to 15 minutes of your time. These questionnaires will be evaluated by the researcher and a report on the findings will be mentioned in the master thesis publication as well as used for further progress of this project.

Your name will not be disclosed or use for anything other than the purpose of this research and the questionnaire is **anonymous**. Participation in the study is strictly voluntary and participants can withdraw at any time, without giving a reason.

The consumer experience observation will be **video recorded**. Only parts from neck and below will be taken. These footages will strictly be used only for the purpose of this project and **will not be published** in any graphical manner.

If you have any further questions please ask the researcher now or after you have completed the task. You will be given contact details in case you have a query at a later date. Any consent that are not mentioned in this form are opened for further discussion with the researcher.

Participants must complete the consent form below before taking part in the consumer experience test.

Please Tick (✓)

- I confirm that I have read and understood the above information and have had the opportunity to ask questions
- I understand that if I have any further questions about the research or need to discuss it further, the researcher will be available.
- I understand that my participation is strictly voluntary and that I am free to withdraw at any time, without giving reason
- I understand that this consent form shall be kept confidential and that my details will not be disclosed to any third party.
- I understand that a part of this study will be recorded and used for the further evolution of this project.
- I understand that my participation on this study is completely anonymous and that the researcher has no right in any form to mention nor publish my personal information.
- I agree to take part in the above study.

I have read the information given to me and give my consent to take part in the consumer experience test.

Name of Participant

Date

Signature

Name of Researcher

Date

Signature



QUESTIONNAIRE	
Day/Date	Wednesday/ 10th February 2016
Venue	AR Packaging Senior Meetup, Lund, Sweden
Lead Researcher	Santika K. Chenderasa



Development of New Opening and Reclosing Features on Block Cheese Product

Part 1. Answer Before Opening Your Sample

Mark your answer or put a cross (X) along the scaled line

Commercially Available Sample

1. How familiar are you with the particular type and brand of the cheese sample?

Not at all familiar

Very familiar

2. How often do you buy such product?

- a. More than twice a week
- b. Twice a week
- c. Once a week
- d. Twice a month
- e. Once a month
- f. Less than once a month
- g. Never

3. How often do you have spoiled leftover (wasted) this product?

Never

Often

4. Any comments about the packaging?

Part 2. Answer After Opening Your Sample

Commercially Available Sample

1. How satisfied are you with your experience in opening the packaging?



Blank Sample

1. How satisfied are you with your experience in opening the packaging?



2. Is there any difficulty during the opening of the package?

- a. No
- b. Yes, because _____

3. Any comment about the blank sample?



MEDGIVANDEFORMLÄR	
Datum	Onsdagen den 10 Februari 2016
Plats	AR Packaging Pensionärklubban, Lund, Sweden
Studieansvarig	Santika K. Chenderasa



Utveckling av öppnings- samt återförslutningsfunktion för trekanstostar

Den här studien är del av ett Examensarbete på Lunds Tekniska Högskola. Du kommer bli tillfrågad delta i ett användbarhetstest samt att besvara några frågor.

Totalt kommer 30 volontärer bli ombudda att använda dessa förpackningar. Närmare instruktioner kommer att ges innan testet startas. Testet tar vanligtvis 10 till 15 minuter av din tid. Testet och enkäten kommer att utvärderas av studieansvariga och resultaten kommer att publiceras I Examensarbetets Rapport samt att användas för att vidareutveckla förpackningen.

Testet och enkäten är anonyma och ditt namn kommer inte användas mer än för den här studien.

Deltagandet i den här studien är helt frivillig, du kan när som helst avsluta utan att uppge anledning.

Användbarhetstestet kommer att filmas. Det filmade materialet kommer endas användas inom den här studien samt för internt bruk på Flextrus AB, materialet kommer inte publiceras i tryckt eller digital form.

Om du har några frågor så är du välkommen att ställa dem både nu eller efter att du deltagit i studien. Du kommer få kontaktuppgifter till studieansvariga utifall du kommer på några frågor efter hand. Om du har några punkter som inte är nämnda i det här formuläret, är du välkommen att diskutera dem med studieansvariga.

Deltagare måste fylla i medgivandeformuläret innan de deltar i användbarhetstestet

Fyll I med en bock (✓)

- Jag medger att jag ger last och förstått informationen ovan samt att jag har haft möjlighet att ställa frågor.
- Jag förstår att om jag har fler frågor angående studien eller behöver diskutera den vidare, så är studieansvariga tillgängliga.
- Jag förstår att deltagandet i den här studien är helt frivilligt och jag kan när som helst avsluta utan att uppge anledning.
- Jag förstår att det här medgivandeformuläret kommer hållas konfidentiellt och kommer inte distribueras med tredje part.
- Jag förstår att delar av det här testet kommer spelas in för att användas senare i utvecklingsprojektet.
- Jag förstår att mitt deltagande i den här studien är helt anonymt och att studieansvariga inte har rätt att i någon form nämna eller publicera min personliga information.
- Jag avger mitt medgivande till att delta i ovan nämnda studie.

Jag har läst informationen ovan och ger mitt medgivande till att delta i användbarhetstestet.

Deltagarens namn

Datum

Signatur

Studieansvarigs namn

Datum

Signatur



ENKÄT	
Datum	Onsdagen den 10 Februari 2016
Plats	AR Packaging Pensionärklubban, Lund, Sweden
Studieansvarig	Santika K. Chenderasa



Utveckling av öppnings- samt återförslutningsfunktion för trekantostar

Del 1. Fyll i innan du öppnar förpackningen

Markera ditt svar genom att sätta ett kryss (X) på linjem

Kommersiell ostförpackning

1. Hur väl känner du till den här specifika typen av ost samt dess varumärke?

Känner inte alls till

Känner mycket väl till

2. Hur ofta klper du den här typen av produkt?

- a. Flera gånger i veckan
- b. Två gånger i veckan
- c. En gång i veckan
- d. Två gånger på månad
- e. En gång på månad
- f. Mer sällan än en gång per månad
- g. Aldrig

3. Hur ofta har du problem med att den här typen av product blir dålig, så att du måste slänga hela eller delar av den?

Aldrig

Ofta

4. Några kommentarer gällande förpackningen?

Del 2. Fyll I efter att du öppnat förpackningen

Kommersiell ostförpackning

1. Vad tycker du om att öppna förpackningen?



Tom förpackning

1. Vad tycker du om att öppna förpackningen?

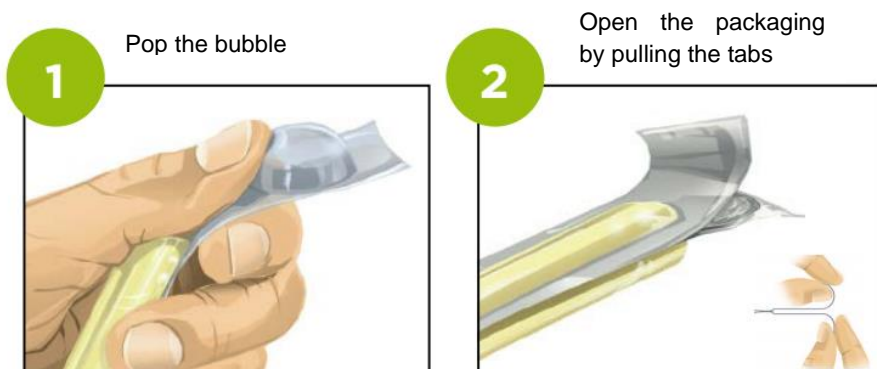


2. Hade du problem med att öppna förpackningen?
 - a. Nej
 - b. Ja, för att _____
3. Några kommentarer gällande den tomma förpackningen?

Appendix 2. Opening Instruction

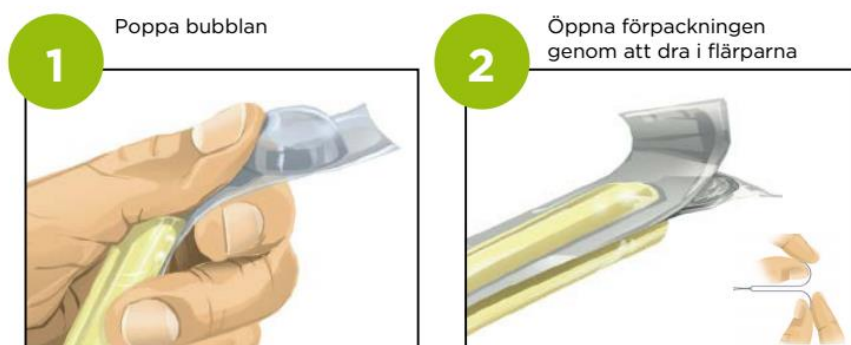
English Version

OPENING INSTRUCTION



Swedish Version

ÖPPNINGSSINSTRUKTIONER

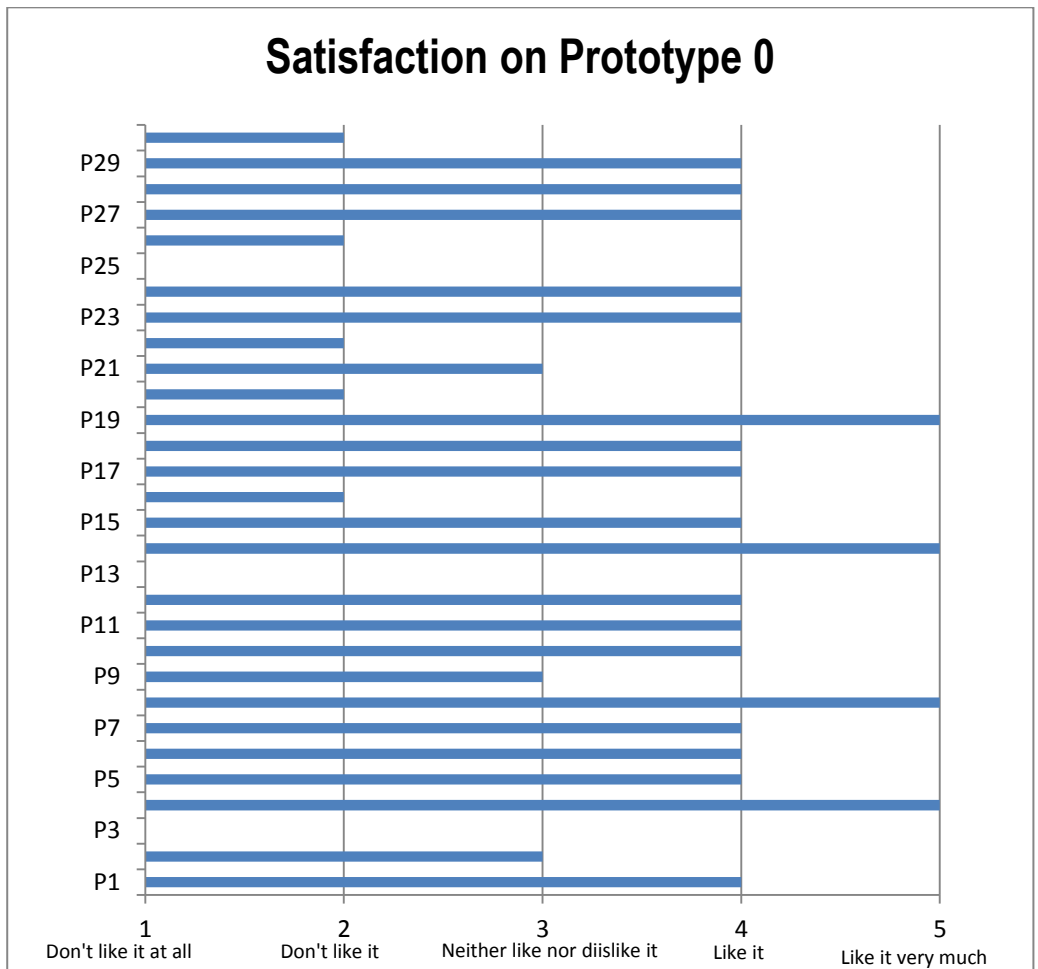


Appendix 3. Scoring Form

Scoring Test P1/P2/P3

Criterion	Weight (1-5)	Score (1-10)	Notes
Bubble A			
Popping the bubble helps you to open the packaging	5		
Popping sound is /ågom	2		
Peeling the lid can easily be done	4		
Bubble has an attractive shape/size	1		
Easy to Understand Concept	3		
Total Score			
Bubble B			
Popping the bubble helps you to open the packaging	5		
Popping sound is /ågom	2		
Peeling the lid can easily be done	4		
Bubble has an attractive shape/size	1		
Easy to Understand Concept	3		
Total Score			
Bubble C			
Popping the bubble helps you to open the packaging	5		
Popping sound is /ågom	2		
Peeling the lid can easily be done	4		
Bubble has an attractive shape/size	1		
Easy to Understand Concept	3		
Total Score			

Appendix 4. Detailed Results on Prototype 0 Satisfaction



Appendix 5. Interview Questions

1. Interview to **machinery expert** (Bobby Micevski, External Technical Service, Flextrus AB)
 - a. What kind of technology is normally used in cheese packaging line?
 - b. How does the machine work principally?
 - c. What are the parts of the machine?
 - d. What are the controllable parameters for different parts of the machine?
2. Interview to **analysis specialist** (Hakan Arnfors, Laboratory Engineer, Flextrus AB)
 - a. Which factors influence the nominal forces measured by the test?
 - b. What is the range of desirable peel strength on packaging?
 - c. Is there any difference on the desirable peel strength for different kind of packaging? What are the factors influencing it?
3. Interview to **product expert** (Jimmy Anderberg, Technical Product Manager, Flextrus AB)
 - a. What kinds of materials are normally used for top and bottom web on cheese packaging?
4. Interview to **customer specialist** (Marina Bergin, Internal Sales, Flextrus AB)
 - a. How does the cheese packaging patterned on the reels of material?
 - b. What are the measurements of the reel? Who sets these measurements?
 - c. How are the reels stacked on a pallet?
 - d. How are the pallets delivered to customer?
 - e. Who did the graphical design?