The value of rib design in food packaging: from packaging company and consumer perspectives

THU HUA THUAN ANH

MASTER´S THESIS

Packaging Logistics
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Thu Hua Thuan Anh

Lund 2015

Abstract

Title: The value of rib design in food packaging: from packaging company and consumer perspectives

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Issue of study: Ribbing is a popular design feature that has been applied for a long time to food packaging, especially plastic bottles and metal cans. However, a comprehensive understanding of the functions of ribs on food packaging has not been fully achieved yet. Recently, the Tetra Pak Material Treatment team has started to get interested in developing innovative carton containers which are inspired by rib designs. To apply ribs to carton containers, there is a research demand of exploring all ribs' functions on food packaging and the consumers' perception toward rib designs. Based on the findings, innovative rib design concepts for Tetra Pak carton containers are proposed.

Purpose: The purpose of this master thesis is firstly to map all functions of ribs on food packaging based on the evaluation in all aspects of a packaging system. These include technical, economic, environmental, and marketing aspects as well as consumer convenience. The second purpose of the thesis is to propose rib design concepts for Tetra Pak carton containers.

Method: To fulfil the research purpose, both qualitative and quantitative research are employed. The empirical data is collected by face-to-face surveys and personal observation on 100 Swedish consumers in two independent consumer studies. Collected data is analysed and compared by a statistical method (Chi-square test). Finally, a mind-map model is used to construct all ribs' functions on food packaging based on the findings of the consumer and the literature research.

Conclusion: Rib designs applied to food packaging have both advantages and disadvantages but the former surpasses the latter. Originated from the demand of preventing deformation, ribs are applied to food packaging and lead to other advantages.

Regarding technical functions, rib designs help to increase top load strength, enhance resistance to bending, reduce the amount of packaging materials, and protect coating layers of metal sheets used to make cans from cracks, corrosion, and leakage. For carton materials, rib designs can create a thermal insulation function and optimize product stability. Regarding economic functions, rib designs help to minimize costs from using less packaging materials, increasing production capacity and transportation efficiency, and from less damaged products. Moreover, appealing rib designs also help to increase sales. In addition, rib designs support to decrease negative environmental impacts by reducing natural resource usage, energy consumption, and emissions caused by production and recycling processes of packaging. However, rib designs carry some disadvantages related to label adhesiveness, non-standard stacking, and high investment costs.

In terms of marketing, rib designs can enhance aesthetic appearance of packaging, differentiate products, shape brands, and prevent counterfeiting. In the perception of researched Swedish consumers in these studies, rib designs support convenience by making packaging more tightly fit on their hands and more rigid when grabbing, especially for large packages. In addition, consumers are willing to pay more for packaging that provides increased convenience or has less negative environmental impacts. However, rib designs may obstruct readability of product information.

The thorough understanding of the functions of ribs and the perception of consumers toward ribs creates a basis for proposing ten design concepts of ribs for Tetra Pak carton containers. In addition, insights into what drives consumers' purchasing decision help Tetra Pak to develop carton containers with ribs that approach successfully their target consumers and at the same time surmount one main ribs' disadvantage.

Key words: Reinforcing ribs, food packaging design, Swedish consumers' perception, Swedish consumers' purchasing driven.

Executive summary

Introduction

Packaging and packaging design play an important role in food supply chains. Nowadays, with more competition, companies need to carefully consider their packaging designs and innovate continuously designs to enhance their competitiveness. Tetra Pak is not an exceptional case. Recently, the Tetra Pak Material Treatment team has started to get interested in rib designs and wants to apply these designs on Tetra Pak carton containers.

Ribbing is a popular design feature that has been applied for a long time to many food packages, especially plastic bottles and metal cans. However, a comprehensive understanding of the functions of ribs on food packaging has not been fully achieved yet. Lacking of this understanding brings Tetra Pak difficulty in evaluating whether their carton containers can inherit the rib design with its functions or not. Besides, missing the consideration of rib's drawbacks may lead to risks for the company when the ribs are applied on their carton containers. Therefore, there is a research demand of exploring all advantages and disadvantages of the ribs on plastic bottles, metal cans, and other food packaging. Based on the findings of this research, the company will be able to evaluate if their carton containers can inherit the rib's benefits and overcome the disadvantages of the rib design.

In addition, the team is interested in understanding the general perception of Swedish consumers toward the rib design as well as which rib designs on food packaging are favoured by Swedish consumers. Therefore, there is a demand of researching Swedish consumers to know their perception toward the rib design and their most favourite rib design on Tetra Pak carton containers. Based on that, the team can choose the right design of ribs to apply for ensuring a high success ratio of a new Tetra Pak container on the Swedish market.

Objective

The main purposes of the master thesis is to:

- ❖ Map all functions of ribs on food packaging based on the evaluation in all aspects of a packaging system, from technical, economic, environmental aspects to marketing and consumer convenience.
- ❖ Propose rib design concepts for Tetra Pak carton containers.

Methodology

The research process carried out in this thesis is designed by combining quantitative and qualitative research. In particular, it consists of a literature research on food packaging with ribs, and two consumer studies which include face-to-face surveys in parallel with observation on 100 Swedish consumers. The collected empirical data is analysed and compared by a statistical method - Chi-square test. Finally, a mind-map model is used to construct all ribs' functions on food packaging based on findings of the consumer and the literature research. The map of the ribs' functions and the in-depth understanding of the consumer perception create a basis for selecting the utmost potential rib designs to propose for Tetra Pak carton containers.

Results

Results from literature research

According to the literature research, the technical functions of rib designs on food packaging include (1) preventing deformation caused by the sterilisation process and external pressures, (2) increasing top load strength, (3) enhancing resistance to bending, (4) reducing packaging materials and weight, (5) protecting coating layers from cracks, (6) assisting a sterilisation process, (7) creating thermal insulation, and (8) maintaining the appearance of product packaging. Besides, rib designs help to minimize costs thanks to less packaging materials, high production and transportation efficiency, and less damaged products. Rib designs support reducing negative environmental impacts, such as reducing natural resource usage, energy consumption, and emissions caused by the production and the recycling processes. In terms of marketing and consumer convenience, ribs' applications provide better aesthetic appearance for packaging. However, if ribs are not designed in an appropriate way, they can hinder label and stacking processes as well as require high investment cost.

Results from consumer studies

Regarding metal cans, ribs do not provide any convenience functions for holding. Furthermore, the ribs reduce the readability of product information on cans' bodies.

Regarding plastic bottles, rib designs make plastic bottles more appealing and more convenient during handling and use. In terms of aesthetic appearance, the consumers prefer wavy ribs in vertical direction. With large bottles, the consumers prefer deep ribs over shallow ribs regarding the convenience.

Regarding drivers for purchasing decisions of the consumers in both groups, the most persuasive criterion that the consumers are willing to pay more for is environmental friendliness. Convenience and aesthetic appearance are important issues to appeal consumers but it is not clear whether the consumers are ready to pay more for them or not.

Comparison between two consumer studies

Regarding the attributes of the two researched groups in the two studies, the groups are different from the age ranges of consumers and the ratios of working areas. The consumers of Group 1 are mainly from 31 to 65 years old while the consumers of Group 2 are mainly from 20 to 40 years old or from 51 to 65 years old. Although there is a difference in the age ranges between the two groups, the largest age range of both groups is 31-40 years old. In addition, the variety of working areas in Group 2 is wider than the one in Group 1. These differences can lead to the difference in the perception of the two groups. Therefore, a statistical method (Chi-square test) is used to check the correlation of the two groups and their perception.

According to the Chi-square tests, there is no significant difference between both groups in the perception and preference toward rib designs on metal cans and plastic bottles. Moreover, there is no significant difference between the two groups toward purchasing decisions. Similar tests between two genders showed the independence between the consumer perception and gender. Therefore, the two groups can be gathered into one big group to evaluate the general perception, preference, and drivers for purchasing decision based on the proportion of consumers' choices.

Discussion

According to 100 consumers' responses, it is hard to conclude that the ribs provide any convenience (handle-ability) for cans in the consumer perception. Indeed, the observation showed that the consumers did not recognize the difference between a non-ribbed can and a ribbed can until the ribs were mentioned. The result can be explained by the fact that metal cans are firm, thus the little added rigidity from ribs' structure is hard to be recognized by consumers. Meanwhile, the metal cans used in these studies are 274ml cans, thus the consumers can hold them easily even for the non-ribbed can. However, it is certainly that the ribbed can is harder to read product information than the non-ribbed can because the ribs create an uneven surface on the can body.

Regarding plastic bottles, the results show that the wavy shape and vertical direction are the most preferred designs of ribs on plastic bottles by the Swedish consumers. Indeed, the observation revealed that some of the consumers who chose the wavy ribs preferred the embossed rectangular shape ribs when visualizing in the beginning. However, when these consumers handled the two bottles, they felt the wavy ribs made the bottle tighter fit their hands. Thus they changed their preference to the wavy ribs. In reality, some consumers are not detail-oriented people or in a hurry. Thus, they may select packages based on the aesthetic appearance rather than take time to "test" packages before buying them. In contrast, if consumers are detailed-oriented or have more time to consider, they may chose packages based on convenience, as what is found in this research. Therefore, in order to attract consumers and create the loyalty to the product brand, packaging companies need to include both attributes - aesthetic appearance and convenience in their design, especially when packaging companies focus on on-the-go products or large containers. In terms of convenience, the deep ribs support the consumers in grabbing heavy bottles easier. According to observation, the female consumers in both groups felt difficulties when handling the large bottle without ribs because they had quite small hands. Most of female consumers commented that the deep ribs helped to lock their hands and prevent the bottle from falling down. Thus, the deep rib design is applicable for large containers and helps packaging companies reach consumers who are women and children.

Regarding drivers for purchasing decisions, 46% of the Swedish consumers taking part in this research are willing to pay more for the aesthetic appearance. Besides, 57% of the consumers are willing to pay more for the convenience function. Indeed, the two largest subgroups in the group who are ready to pay more for the convenience function are the 31-40 year old group and the 51-65 year old group. It can be explained by the fact that normally 31-40 year old people have children and handle large bottles (family size packages) often. Thus together with permanent income, they want to buy convenient packaging for their children to handle for reducing risk of spilling product. For 51-65 year old people, they may not have strong hands to hold large containers and they might have a good financial situation. Therefore, they are ready to pay a little bit more (1kr) for the convenience function. Based on this result, if Tetra Pak targets the 31-40 year old consumers or the 51-65 year old consumers, the company should focus on the convenience function in packaging design. Regarding the environmental performance, 82% of the consumers are ready to pay more for it. It can be explained by the level of education of the consumers in these studies. The researched Swedish consumers are mainly employees in the packaging industry and young students who are living in Lund – a big city in Sweden. As a result, they may have a higher level of education and more recognition toward environmental issues than general consumers. Besides, there is a possibility that some consumers pretend to pay but do not do so in reality. This result indicates that if the company targets urban population, it should insist on the communication of the environmental benefits of the new designs to create a competitive advantage.

Conclusion

Rib designs applied to food packaging have both advantages and disadvantages but the former surpasses the latter. Originated from the demand of preventing deformation, ribs are applied to food packaging and lead to other advantages.

Regarding technical functions, rib designs help to increase top load strength, enhance resistance to bending, reduce packaging materials, and protect coating layers of metal sheets used to make cans from cracks, corrosion, and leakage. For carton materials, rib designs can create a thermal insulation function and optimize product stability. Regarding economic functions, rib designs help to minimize costs from using less packaging materials, increasing production capacity and transportation efficiency, and from less damaged products. Moreover, appealing rib designs also help to increase sales. In addition, rib designs can support to decrease negative environmental impacts by reducing natural resource usage, energy consumption, and emissions caused by production and recycling processes of packaging. However, rib designs carry some disadvantages related to label adhesiveness, non-standard stacking and high investment cost.

In terms of marketing, rib designs can enhance aesthetic appearance of packaging, differentiate products, shape brands, and prevent counterfeiting. In the perception of researched Swedish consumers in these studies, rib designs support convenience by making packaging more tightly fit on their hands and more rigid when grabbing, especially for large packages. In addition, consumers are willing to pay more for packaging that provides increased convenience or has less negative environmental impacts. However, rib designs may obstruct readability of product information.

The thorough understanding of ribs' functions and the consumers' perception provides a basis for proposing ten design concepts of ribs for Tetra Pak carton containers. In addition, insights into what drives consumers' purchasing decision help Tetra Pak to develop carton containers with ribs that approach successfully their target consumers and at the same time surmount one main ribs' disadvantage.

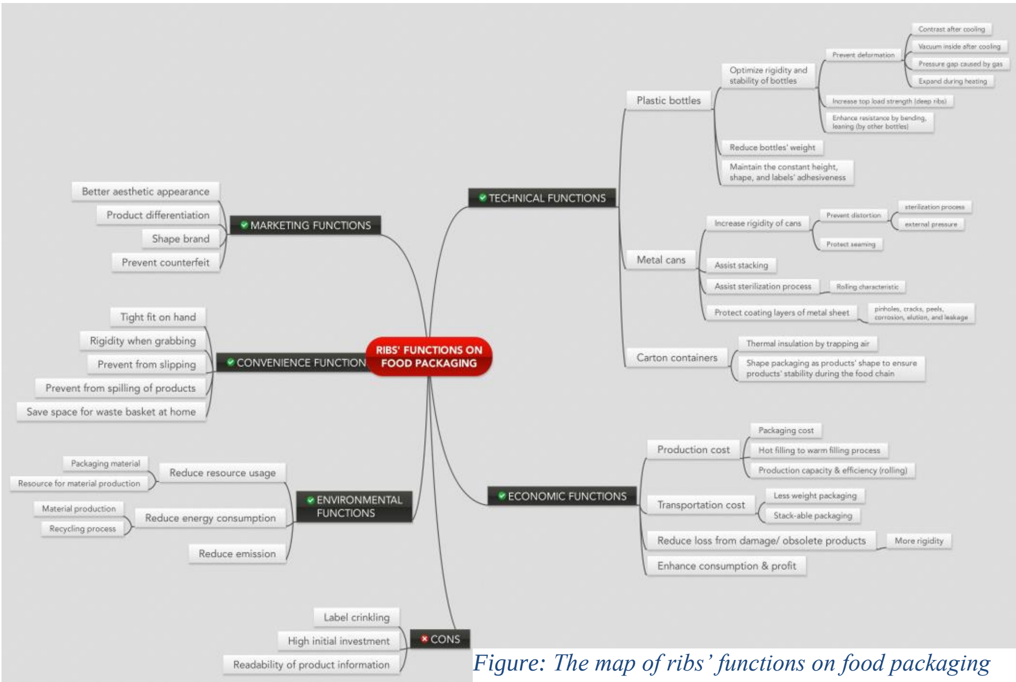

Figure: The map of ribs' functions on food packaging

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1 INTRODUCTION

1.1 Project Background

Packaging and packaging design play an important role in food supply chains. Packaging has many functions such as containment, protection, apportionment, unitization, communication, and convenience (Lockamy, 1995). Particularly in the current dynamic environments with a lot of competition, packaging and its design help to create an initial impression of the product's quality in consumers' mind and to accelerate the purchasing decision. In addition, packaging and its design also shape consumer experience during the consumption stage. Thanks to that, packaging can be considered as a "silent salesman" who plays a very important role in promoting product and companies' brands (Olsson & Larsson 2010, Löfgren 2005).

Moreover, packaging and its design contribute to sustainable development. Sustainable development could be defined as long-term development that satisfies economic requirements, environmental requirements, and social requirements at the same time (Molina-Besch, 2014). An example is the modification of packaging design since it can increase the efficiency of freight transport and decrease food losses along the supply chain. As a result, negative economic, environmental, and social impacts are reduced (Molina-Besch, 2014). Another example is optimizing material usage in a packaging system. It leads to cost savings and the reduction of environmental impacts, including land use, biodiversity, energy consumption, and emissions from production, transportation, and recycling processes. These examples show that just a small change in packaging design can lead to significant impacts in the society and the environment. The important role of the sustainability function of packaging is also verified by the survey of DuPont carried out in North America and Europe, as shown in Figure 1. Among the four main driving forces for "Packaging today and tomorrow", sustainability is the one that has had the highest impact on the packaging industry within the next 10 years since 2012. As the interest for sustainability is growing all around the world, the sustainability function becomes one of the important elements which contribute to the competitive advantage among corporations. Therefore, the sustainability concern in packaging development is the main stream with the significant growth until 2022 (Environmental leader, 2012).

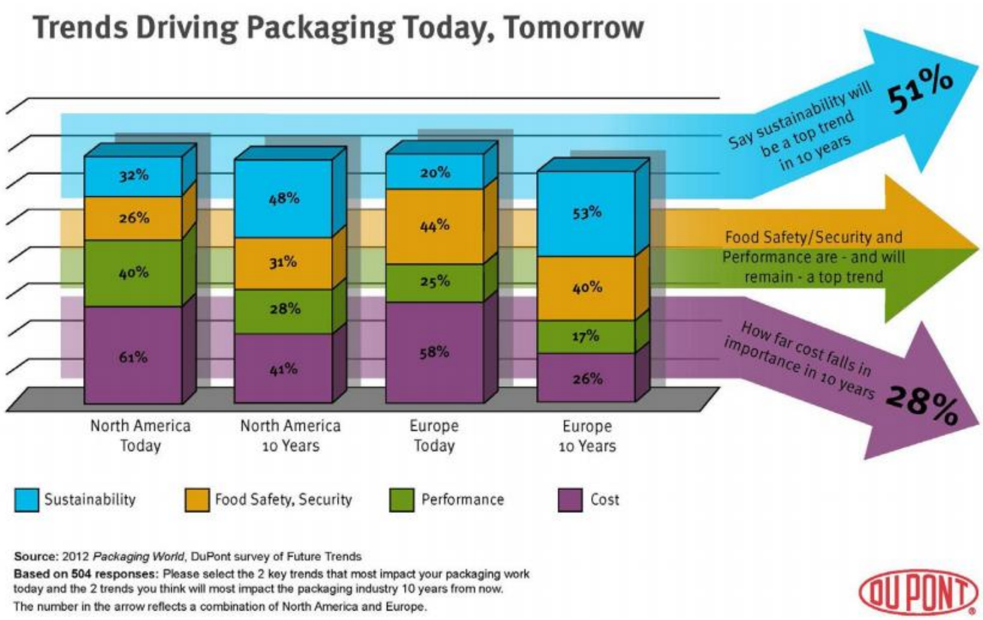

Figure 1: Future driving forces for Packaging as DuPont survey in North America and Europe (Environmental leader, 2012)

Nowadays, with more and more competition, food packaging companies need to carefully consider their packaging designs as well as innovate continuously their products to enhance their competitiveness. Tetra Pak is not an exceptional case. The company needs to continue finding innovative packaging solutions that are multifunctional packaging designs to adapt better to customers' requirements and increase its market in competitive environments. Recently, Tetra Pak Material Treatment team has developed innovative design concepts for Tetra Pak carton containers. After researching some packaging designs, the team is interested in a rib design and wants to apply it to Tetra Pak carton containers.

Ribbing is a popular design feature that has been applied for a long time on many food packages, especially plastic bottles and metal cans. As presented above, whenever a packaging design is applied, it should provide a certain number of functions for a product packaging system. However, a comprehensive understanding of all rib's functions on food packaging has not been fully achieved yet. Lacking of this understanding brings Tetra Pak difficulty in evaluating whether their carton containers can inherit the rib design with its functions or not. Besides, missing the consideration of rib's drawbacks may lead to risks for the company when the ribs are applied to their carton containers. Therefore, to apply the rib design to carton containers, there is a research demand of exploring all advantages and disadvantages of the ribs on plastic bottles, metal cans, and other food packaging. Based on the findings of this research, the company will be able to evaluate if their carton containers can inherit the rib's benefits and overcome the disadvantages of the rib design.

In addition, Tetra Pak Material Treatment team is interested in understanding the general perception of Swedish consumers toward the rib design. The team also wants to know which rib designs on food packaging are favoured by Swedish consumers. Therefore, there is a demand of researching Swedish consumers to know their perception toward the rib design and their most favourite rib designs on Tetra Pak carton containers. Based on that, the team can choose the rib designs to apply for ensuring a high success ratio of new Tetra Pak containers with ribs on the Swedish market.

1.2 Purpose of the research

The purpose of this master thesis is firstly to map all functions of ribs on food packaging based on the evaluation in all aspects of packaging design. These include technical, economic, environmental, and marketing aspects as well as consumer convenience. The second purpose of the thesis is to propose rib design concepts for Tetra Pak carton containers. The research objectives generate three research questions:

Q1. What are the technical functions of rib designs on food packaging as well as the impact of rib designs on economic and environmental aspects?

Q2. What is the Swedish consumers' perception toward the rib design on food packaging?

Q3. Based on the findings regarding technical functions of rib designs (Q1) and the findings regarding consumer perception toward rib designs (Q2), which design concepts of ribs can be suggested for Tetra Pak carton containers?

In order to fulfil the research objectives by answering the questions above, it is necessary to define a clear scope and methodology for the study, which is discussed in the following sections.

1.3 Delimitations

The outcomes of this thesis are the full map of ribs' functions on food packaging and potential rib design concepts to apply to Tetra Pak carton containers. Even though the thesis aims to map up all functions of ribs on food packaging, it will mainly focus on researching ribs' functions on plastic bottles and metal cans because these food packaging types are the main ones where ribs are widely applied to.

In addition, this research will be based on bibliography research and empirical data from consumer research and personal observation; rather than laboratory testing. The thesis does not collect detailed data of economic and environmental impacts on each commercial packaging with ribs. For instance, how much of greenhouse gas emissions can be reduced by integrating rib designs on food packaging is out of the scope of the thesis project.

Besides, the master thesis' research has the following limitations:

• The interviews with the Swedish consumers in face-to-face surveys are held in English. As the native language of consumers and the interviewer are not English, the depth of discussions may be limited.

• Since the concept of ribs on carton containers is quite new, there are very few applications in the packaging industry. Therefore, in the consumer research, the packaging samples with ribs are some current plastic bottles and metal cans with rib designs. To check the favourite rib designs for carton containers, some draft pictures of rib designs are glued on the blank carton packaging for visualization. Consequently, the experience of consumers toward the rib designs on carton containers is limited.

• The consumer research is conducted with the Swedish consumers in Lund city. Thus, conclusions about the consumer perception toward rib designs on plastic bottles and metal cans might not be representative of Swedish consumers in other areas in Sweden.

• The proposed design concepts of ribs for Tetra Pak carton containers are based on the research with the Swedish consumers who are working in the packaging industry. Thus, conclusions about the rib design preference on carton containers present only for the opinions of these consumers. This might not be representative of other consumers.

This master thesis is written under the main supervision from Lund University in cooperation with Tetra Pak Material Treatment team. This research is also sponsored by the Material Treatment team. This work aims to provide the team a thorough understanding of ribs' functions on food packaging and the Swedish consumers' perception toward the rib design. At the same time, the research points out potential designs of ribs for Tetra Pak carton containers.

2 METHODOLOGY

This chapter presents the way of approaching the research objectives and the method chosen to achieve the goal. The chapter consists of three parts explaining in detail (1) the research process, (2) the research method, and (3) the data collection and data analysis techniques.

2.1 The Research Process

The research process carried out in this thesis is visualized as shown in Figure 2. The research is designed by combining quantitative and qualitative research. In particular, it consists of literature research on food packaging with ribs, and consumer research which includes both face-to-face surveys in parallel with observation on Swedish consumers. Based on the collected data, the mapping of ribs' functions on food packaging and the proposing of rib design concepts for Tetra Pak carton containers are carried out.

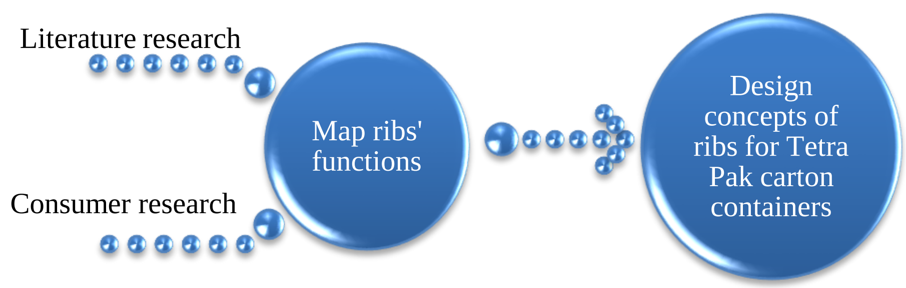

Figure 2: The research process

2.2 Quantitative and Qualitative Research

After conducting the literature research, the consumer research is carried out by combining two methods - quantitative and qualitative research. According to Hoepfl (1997), the quantitative research refers to employing experimental methods and quantitative measures to test hypothetical generalizations. This paradigm has four main characteristics, including (1) fact measurements and cause analysis of behaviour, (2) quantifying and summarizing data under the form of numbers, (3) analysis of the numeric data by a mathematical process, and (4) using statistical terminologies to express results (Charles C.M. 1995, Golafshani 2003). On the other hand, the qualitative research is defined as any kinds of research that seeks understanding and extrapolation to similar situations (Hoepfl, 1997), instead of emphasizing on numbers like the quantitative research. Besides, there are some significant differences relating to research tools and the involvement of a researcher during a data collection process between the two research methods. For instance, while a quantitative research's tool is usually a survey; qualitative research's tools are interviews and observation (Arksey & Knight, 1999). In addition, quantitative researchers try to disassociate themselves as much as possible during the research process to keep the integrity and objective of collected data. On the contrary, qualitative researchers involve themselves into a research to explore as much as possible relevant information they want (Winter, 2000).

In this thesis, the research is based on the combination of quantitative e and qualitative research, in particular, face-to-face surveys and personal observation. Thanks to this combination, the primary data (empirical data) is collected. The primary data integrated with the secondary data (from articles, conference proceedings, company development reports, patents) provides a thorough understanding for answering the research questions mentioned in Chapter 1. The validity of the research is ensured by making questions used in the consumer research clear, understandable, and unbiased. The questions are also reviewed and reformulated according to results from trial testing on some consumers before being used for the official consumer survey.

2.3 Data Collection and Data Analysis

In this thesis, both primary and secondary data are collected. While the secondary data is collected during the literature research stage, the primary data is gathered from the consumer research stage.

2.3.1 The first stage: literature research

According to Carson et al. (2001), literature research creates a foundation of a theoretical framework for further empirical research such as interviews and surveys. Thus, the first stage of this thesis is the literature research which aims to collect the secondary data about all functions of rib designs applied to metal cans, plastic bottles, and food packaging in general. The resources used in the literature research consist of relevant company development reports, patents, scientific publications from Lund University database, and online sources. The key words which are used to search include reinforcing ribs, containers with reinforcing means, adjacent annular grip, bottles / metal cans / carton containers comprising of ribs, ribbing, deep/ shallow/ flat rib portions, circumferential stiffening rib, rib design, and contours on bottles. The search engines used include Google, Espacenet, ScienceDirect. Functions of rib designs are gathered into various groups in relation with aspects of packaging design, from technical, economic, environmental to marketing and consumer convenience. This stage is conducted within five weeks, from the 15th of January to the 20th of February.

The results from the literature research are used to answer the first research question (Q1) presented in Chapter 1.

2.3.2 The second stage: consumer research

2.3.2.1 Data collection

The consumer research is carried out on Swedish consumers to explore their perception toward rib designs on plastic bottles and metal cans. Moreover, the research points out the favorite rib designs on plastic bottles and carton containers in the perception of Swedish consumers. The research also helps to check the importance of some specific criteria that might affect the purchasing decision. These criteria include price, environmental issues, convenience, and aesthetics. The consumer research is designed according to both quantitative and qualitative researches which are face-to-face surveys and observation.

The face-to-face survey is used to collect the quantitative data about the consumer perception of rib designs on food packaging. Firstly, the survey tests if the Swedish consumers like the rib design on metal cans and plastic bottles. Secondly, the survey explores which rib designs are favored by the Swedish consumers, in the case of plastic bottles and in the case of carton containers. The consumers are asked to select the most favorite rib design among a number of rib designs which are different in the directions, shapes, and depths of ribs. Eventually, the consumers need to state if they are willing to pay more for certain packaging's attributes including aesthetic appearance, convenience, and environmental sustainability. In addition, the observation helps to explore if (1) the consumers recognize ribs, (2) the consumers encounter any inconvenience when holding packaging without ribs and why, and (3) there is any reason for their preference design.

However, there could be a case that some consumers are not aware of rib design or cannot recall their experience with it. To overcome this issue, some specific packaging samples with the rib design are given to consumers to practice on it. Packaging samples used in the consumer research are existing plastic bottles and metal cans with rib designs in the Swedish market. Besides, rib designs on carton containers are 2D drawings which are glued on blank carton containers. Based on that, the consumers easily get the notion of ribs and are able to express their impression immediately instead of recalling their past experience. At the same time, the researcher can observe the consumers' actions to understand their selections. The consumer research is done in English. For details of the questionnaires, see Appendix A and B.

Thanks to the combination of face-to-face surveys and observation, the consumer perception of rib designs and the most favourite designs of ribs for Tetra Pak carton containers to approach the Swedish market are revealed.

Due to the confidentiality of the research, the consumer research is divided into two consumer studies which are applied to two different groups. The first consumer study is carried out on 50 consumers who are working in the Swedish packaging industry (they can be administrators or sellers within the industry) (Group 1). The second consumer study is carried out in Lund retail stores or on streets also on 50 Swedish consumers (Group 2). The difference between the two consumer studies is that the Group 1 is asked about rib designs on plastic bottles, metal cans, and carton containers while the Group 2 is asked only about rib designs on plastic bottles and metal cans. The consumers are chosen randomly depending on their willingness to participate in the studies. However, in order to increase the credibility of the research, the ratio between female and male consumers is 1:1 and the age range is 20 to 65. The gender ratio and age ratio are selected based on the current demographic of Sweden reported in “Sweden age structure” by Indexmundi (2014). It should be noted that the two consumer studies are conducted only at Lund city because the company wants to keep the confidentiality of the research. Moreover, Lund is also a big city with the population that is about 10% of the Swedish population (Countryeconomy 2014, Lund 2015). Therefore, together with the random selection of Swedish consumers in Group 2 at stores or on streets, the consumers of Group 2 can represent targeted Swedish consumers of the company, according to the representative of the Material Treatment team. For the consumers of Group 1, one point should be noted that they are working in the packaging industry. Thus, they may have higher concern about the packaging’s aesthetic appearance than the general Swedish consumers.

The consumers in each study are divided into different age groups including (1) less than 20 years old, (2) 20-30 years old, (3) 31-40 years old, (4) 41-50 years old, (5) 51-65 years old, and (6) more than 65 years old. Furthermore, for comparing results of the two consumer studies later, the proportion of these age groups in the two studies should be similar. For instance, if the proportion of the 31-40 years old group in the first study is 36%, the proportion of the 31-40 years old group in the second study should be around 36%. Because the consumer study on the Group 1 is conducted first, the proportions of the different age ranges in the Group 2 are selected based on the ones in the Group 1. Table 1 provides an overview of the consumer studies performed with Group 1 and Group 2.

Table 1: Comparison between the two consumer studies

<table>
<tr><th></th><th>Group 1</th><th>Group 2</th></tr>
<tr><td>Consumers</td><td>Swedish consumers who are working in the packaging industry</td><td>Swedish consumers who are selected randomly at stores or on streets (not work in the packaging industry)</td></tr>
<tr><td>Research objects</td><td>Carton containers, plastic bottles, metal cans</td><td>Plastic bottles, metal cans</td></tr>
<tr><td rowspan="4">Explore</td><td colspan="2">Whether Swedish consumers like rib design on metal cans and plastic bottles or not</td></tr>
<tr><td colspan="2">Rib designs which are favored by the Swedish consumers</td></tr>
<tr><td colspan="2">Does rib design provide any convenience?</td></tr>
<tr><td colspan="2">Whether Swedish consumers are willing to pay more for aesthetics, convenience, and environmental friendliness.</td></tr>
</table>

This stage is conducted within four weeks, from the 23rd of February to the 23rd of March. The plan is prepared during the first week and the consumer studies are carried out during the last three weeks.

2.3.2.2 Data analysis

The quantitative data collected from each consumer study is analysed to approach the research's objectives. In addition, the observation is described in text form and interpreted to get in-depth insight of the consumers toward rib designs on plastic bottles and metal cans.

Next, the results of the two consumer studies are compared to each other by using a Chi-square test. The chi-square test is used as a guideline for declaring if the collected data is strong enough to generalize that there is a statistically significant relationship occurred between two groups (The Pennsylvania State University, 2007). The chi-square test is chosen among correlation tests to apply in this case because the two variables - group and perception are qualitative variables (StatPac Inc., 2014). In this study, the two research groups might be different in some attributes such as working areas, income. Thus, it is necessary to know if these attributes affect their perception toward the rib design on plastic bottles and metal cans as well as factors influencing their purchasing decision. By using a Chi-square test, the data of the two groups is analysed for generalizing that if the selection or perception of the two groups is independent to their attributes.

According to StatPac Inc. (2014), there are three critical steps to implement the Chi-square test. The first step is deciding a critical alpha level and a null hypothesis. The critical alpha level α is 0.05 as per usual, and the null hypothesis is: "there is no significant difference in perception between Group 1 and Group 2". The identification of the critical alpha level α is the base for determining the critical value from a Chi-square table (Appendix C) for further comparison (European Commission Joint Research Centre, 2015). The second step is calculating the statistic of the collected data from the consumer studies as following formula (I):

$$\chi^2 = \sum \frac{(O - E)^2}{E}$$

In the formula, *O* represents the observed frequency. *E* is the expected frequency under the null hypothesis and calculated by:

$$E = \frac{Row\ total\ x\ column\ total}{Sample\ size}$$

The statistic is also calculated by using the formula CHISQ.TEST (II) in Excel. However, the formula (II) is used calculate the probabilityρ, instead of the value χ^2 as the formula (I) above. After having the statistic, the final step is comparing the statistic to the critical value or critical alpha level α chosen. If the statistical value χ^2 is higher than the critical value or the probability ρ is less than the critical alpha level α, the null hypothesis is rejected. In this case, the two groups have different perceptions affected by their attributes. In contrast, the null hypothesis is failed to be rejected and the two groups have the similar perception although their attributes are different (The Pennsylvania State University, 2007). Consequently, the consumer perception toward ribs on food packaging and their purchasing-driven is concluded concretely.

Table 2 below is the summary of possible results from the two consumer studies.

Table 2: Summary of data from the two consumer studies

Data summary		Group 1	Group 2
Result	Carton containers	Design A	
	Plastic bottles	Design & Perception B	Design & Perception C
	Metal cans	Perception D	Perception E

When comparing the two consumer studies, there are only two possibilities. The first possibility is that the two groups have the same favourite designs and perception toward ribs on plastic bottles and metal cans (design & perception B = design & perception C and perception D = perception E). The second possibility is that the two groups have the different favourite designs and perception toward ribs on plastic bottles and metal cans. In each hypothesis, there are some conclusions that can be withdrawn as following:

❖ ***Possibility 1***: If the two groups have similar choices (design & perception B = design & perception C ***and*** perception D = perception E), and the Chi-square test points out that the perceptions of two groups are independent with their attributes, it can be concluded that:

1. Group 1 has the same perception as Group 2.
2. The favourite rib design on plastic bottles is the design B.
3. The researched Swedish consumers' perception toward ribs on metal can is the D one.
4. The general perception toward rib designs on food packaging and purchasing-driven of the Swedish consumers is based on the results of the two groups.

❖ ***Possibility 2***: If the two groups have different choices (design & perception B # design & perception C ***and/or*** perception D # perception E), ***and/or*** the Chi-squared test points out that there is significant difference between the two groups in their perception, it can be concluded that:

1. Group 1 and Group 2 have different perception.

2. The perception toward rib designs on food packaging and purchasing-driven depend on each group of consumers.

The obtained data from the consumer research and the literature research is collated to identify common patterns among the roles of rib design on food packaging in terms of consumer perception. This stage is conducted within three weeks, from the 24th of March to the 14th of April.

The analytical results withdrawn from the consumer research are used to answer the second research question (Q2) presented in Chapter 1.

2.3.3 The third stage: mapping ribs' functions and suggest design

Based on the findings regarding technical functions of rib designs (Q1) and the findings regarding consumer perception of rib designs (Q2), a model reflecting all ribs' functions on food packaging is built by using mind map tool. According to Carson et al. (2001), a model should be used to construct a framework which helps a researcher to describe and confine a research to a clear course of action. Therefore, in this thesis, the model is built to visualize all functions of ribs on food packaging, including technical, economic, environmental ones as well as marketing and consumer convenience. This map is constructed by the secondary data obtained from the literature research and the empirical data gained from the consumer research. This stage is conducted within a month, from the 15th of April to the 14th of May.

The map of ribs' functions and the in-depth understanding of consumer perception create the concrete fundamentals to select utmost potential rib designs in order to propose for Tetra Pak carton containers. Thanks to that, the third research question (Q3) presented in Chapter 1 is answered.

3 THEORETICAL FRAMEWORK

This chapter presents the results of literature research, including the background of ribs' applications on plastic bottles, metal cans, and carton containers. In addition, some commercial rib packaging samples are evaluated to get the holistic understanding of the value of ribs on food packaging.

3.1 Background of ribs' applications on plastic bottles

In the past, the beverage industry employed glass containers to deliver liquid beverages. However, thanks to many advantages including cost, production efficiency, lightweight, and breakage ratio, plastic containers have gradually replaced glass ones. Among many plastic materials, polyethylene terephthalate (PET) or polypropylene (PP) is used more frequently. Normally, they are formed by blow moulding method- the traditional and cheapest technique. Besides the single form, these materials can be cooperated with a barrier layer, for example, ethylene vinyl alcohol (EVOH) for the inhibition functions from gases or moisture's migration (Hanan & Peykoff 2013, Rashid 2001).

3.1.1 Non-carbonated beverage industry

In the non-carbonated beverage industry, plastic materials have many advantages over glass materials such as durability and light weight. However, they are easily to be deformed. The reason of deformation might come from a thinner wall of a plastic bottle. Moreover, the non-carbonated beverages are necessary to be sterilized or pasteurized to ensure sanitation requirements before they are delivered to customers. The sterilization or pasteurization processes normally lead to the deformation of plastic bottles (Rashid, 2001).

The first process applied for plastic bottles in the non-beverage industry is the hot filling process. In this process, the plastic bottles are filled and sealed while the beverage's temperature remains high, around 85°C. With the high filling temperature, the beverage can be protected from threatening microorganisms which may come from packaging and the external environment. Then, the beverage is cooled down inside the bottle, from the sterilized temperature to the room temperature. During the cooling process, the internal pressure of the bottle is dropped off because of the shrinkage of liquid inside and the condensation of air in the bottle's head space. As the internal pressure of the bottle drops, the external pressure from environment will be higher than the internal pressure. Consequently, the gap of those pressures creates the inward deformation of the bottle (Rashid, 2001). Figure 3 below illustrates the bottle before hot filling and the distorted bottle after cooling down (Outreman, 2011).

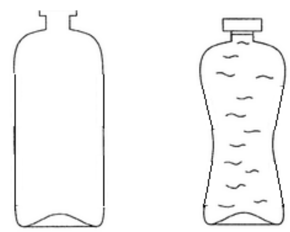

Figure 3: Bottle before hot filling (left) and distorted bottle after hot filling (right) (Outreman, 2011)

The second process applied for plastic bottles in this industry is the pasteurization process after filling. In this process, the plastic bottle and its content are raised to a desired temperature in a desired period of time to kill organisms inside the bottle and the beverage. Because the bottle has already been sealed before this process and is increased to the same temperature with the beverage, the internal pressure after the bottle is cooled will come back to the status pre-pasteurization. Thus, there is no deformation during the cooling process. However, it may have some outward deformation during the pasteurization process (Rashid 2001). This outward deformation can be seen in the Figure 4 below (Outreman, 2011).

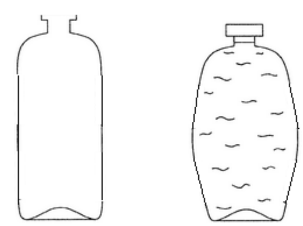

Figure 4: Bottle before filling (left) and bottle suffer outward deformation during the pasteurisation process (right) (Outreman, 2011)

In any cases of deformation, the package has an unappealing distorted shape. Labels applied to those distorted packages are also wrinkled. According to many researches, most consumers believe that products in these distorted bottles have problems and do not buy it. Thus, the distorted bottles not only cause the refusal of products by consumers but also damage the company's brands (Berk O., 2012). The deformation is the motivation for the redesign of plastic bottles in many different ways.

In terms of packaging design, there are two main ways. The first way is to increase the thickness of bottle's wall (Berk O., 2012). Although the idea of increasing wall's thickness works well when the thickness is sufficient, its application faces the barrier of cost and manufacturing efficiency (Rashid, 2001). Therefore, packaging designers started to think about other solutions to enhance the rigidity of plastic bottles without increasing cost. Finally, packaging designers have found the second way which is escalating the structural integrity of the bottle's wall by designing mechanic means such as ribbing or vacuum panels (Berk O., 2012). In this way, the plastic bottle is integrated with various reinforcing means such as ribs, panels, circular groove or ridges which attempt to elevate its resistance to deformation (Rashid, 2001). Accordingly, these designs can work well in preventing deformation without changing materials or increasing cost.

The reason for the technical function of ribs in preventing distortion can be explained by the changing of external forces' directions which affect the bottle's body. When adding ribs or circular grooves to the bottle, they create many curves on the surface of the bottle. Thus, instead of perpendicular directions on the flat symmetry of the bottle's surface, the directions of external forces are disturbed to many directions as shown in Figure 5.

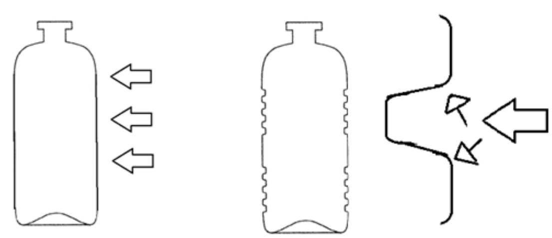

Figure 5: A non-rib bottle with direction of external force (left), a rib-shape one with direction of external force (right)

With the same value of force, the non-perpendicular direction makes less impact than the perpendicular one. Therefore, the feature of ribs reduces the impact of total external forces on the plastic bottle's body.

In addition, the depth of rib also contributes to the distortion prevention. The detailed functions of varying deep ribs are discussed by Hanan and Peykoff 2013. Their research has pointed out that the deep rib portions make the bottle more rigid and stiffer. However, other desired resistances to bending, leaning or stretching in a lightweight bottle are attained by the balanced combination of deep rib, middle rib and shallow rib portions. As seen in Figure 6, at least two shallow rib sections on the bottle's wall vertically line up along the central axis and form a recessed column (7b). This column helps to distribute top load forces (compression forces) when bottles are stacked on top of each other. It also reduces the impact of tangential forces from other bottles along the wall of the bottle. As a result, the inward deformation of the bottle during the hot filling process or other deformation which occurs during packing and transportation are decreased. Meanwhile, the various depths of ribs support maintaining the constant height of the bottle when the bottle is pressurized along the vertical axis. Accordingly, these ribs ensure the adhesiveness of a label to a label portion (Hanan & Peykoff, 2013).

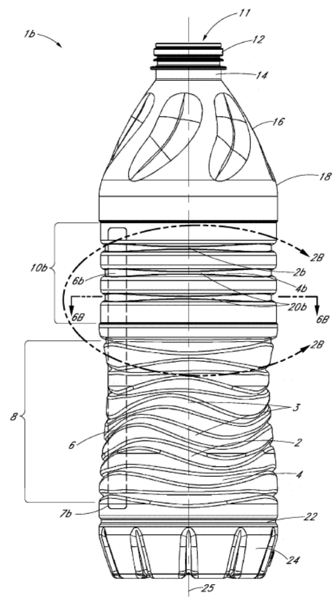

Figure 6: Bottle with varying depth ribs (Hanan & Peykoff, 2013)

Thanks to these technical functions, the ribs are used more and more widely for hot filled plastic bottles. In relation to rib designs, the depth of ribs can be deep (2), middle (4), shallow (6), or the combination with gradual transition or abrupt transition between these rib portions as shown in Figure 6. The shape of ribs applied to plastic bottles is diverse, from squared, oval, triangular, rounded, to hemispherical (Hanan & Peykoff, 2013). Figure 7 shows other rib configurations applied to plastic bottles.

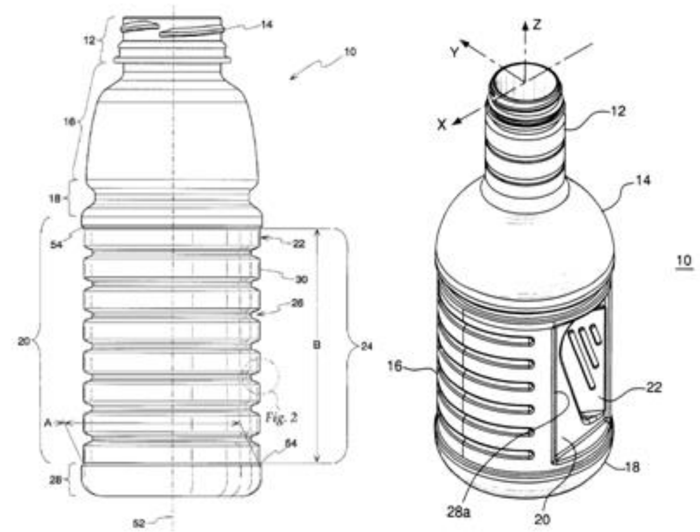

Figure 7: Some rib configurations on plastic bottles (Hanan & Peykoff, 2013)

The typical rib feature applied to PET bottles is the continuous one along the peripheral surfaces of bottles. However, according to Finlay et al. (2001), the discontinuous ribs have higher resistant ability from deformation due to internal and external pressures than the continuous ribs. The graph in Figure 8 shows the stiffness comparison of two discontinuous ribbing containers (Embodiment 1 and Embodiment 2) with a continuous ribbing container (Conventional shell). The two bottles representing embodiment 1 and 2 in Figure 8 are shown in Figure 9 A and Figure 9 B respectively. On the graph, the horizontal axis represents the thickness of the PET 0.5 litter bottles used for the comparison while the vertical axis represents the top load that the bottles can suffer. The top load of bottles is measured by the changing of bottles' diameter when the force is put on bottles. According to the graph, with the same thickness (other dimensions such as a diameter, ribbing areas in the compared bottles are similar); the load of the discontinuous ribbing bottles is higher than the one of the continuous ribbing bottle. The bending stresses are also significantly reduced in the discontinuous ribbing bottles as compared to the conventional continuous ribbing bottle. Furthermore, in the case of the discontinuous ribs, when the rib's size is decreased and the number of ribs is increased, seen in Figure 9 B, the stiffness of the container is even more improved (Finlay et al., 2001).

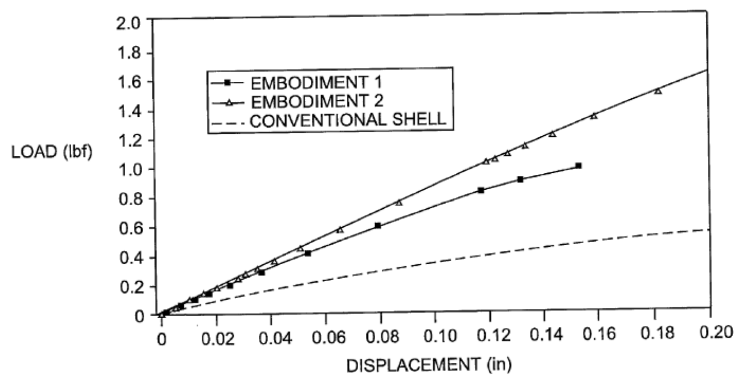

Figure 8: Stiffness comparison of two discontinuous ribbing bottles with a conventional continuous ribbing bottle (Finlay et al., 2001)

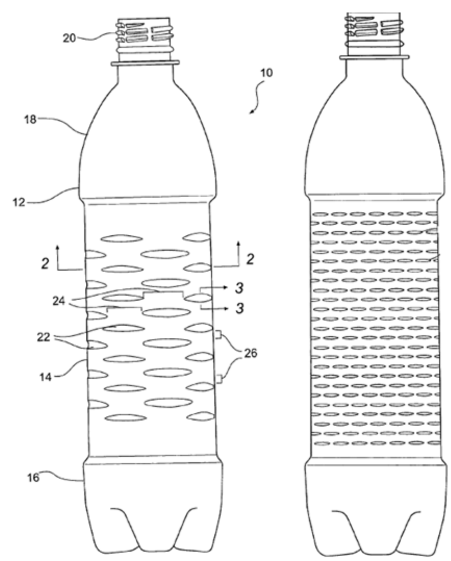

Figure 9: A-Bottle with discontinuous ribs (13 rows of ribs and 5 ribs each row) (left), B-Bottle with discontinuous ribs (25 rows of ribs and 16 ribs each row) (right) (Finlay et al., 2001)

Besides, the orientation of ribs can be modified to the vertical direction. They can also be oriented 30° or 45° relative to the horizontal axis but still achieve the same desired functions mentioned above. Figure 10 A below shows the ribs in the vertical direction and Figure 10 B shows the ribs which are rotated 45° relative to the vertical axis (Finlay et al., 2001).

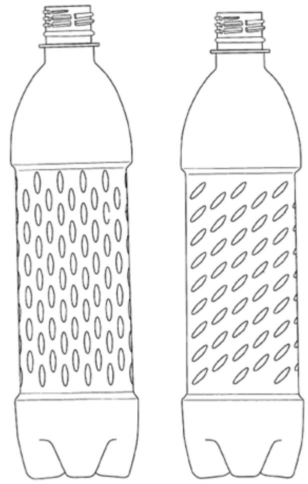

Figure 10: A-Bottle with vertical ribs (left), B-Bottle with oriented ribs 45° relative to vertical axis (right) (Finlay et al., 2001)

In the case of plastic bottles pasteurized after filling, the deformation during the pasteurization process is subsided during the cooling process afterward (Rashid, 2001). Thus, these bottles are normally not redesigned with other reinforcing means.

3.1.2 Carbonated beverage industry

Besides the non-carbonated beverage industry, the carbonated beverage industry also faces similar trouble with the distortion of plastic bottles. However, the deformation comes from another reason. It is recorded that plastic bottles used for this type of beverage are mainly crushed on consumers' hands after opening. As a result, the content of these bottles sprays and disturbs consumers (Boukobza & Guen, 2004).

Boukobza and Guen (2004) pointed out that, when a plastic bottle with a gaseous beverage is closed, pressure of gas inside the bottle exerts force on the surface of the bottle's wall. This force supports to resist the external force exerted by a user to hold it. Subsequently, there is a balance between two forces on the surface of the bottle's body. Therefore, there is no deformation occurred during the time the bottle is closed. However, when the bottle is open, gas inside of the bottle is released. It leads to the reduction of the pressure inside the bottle as well as the force exerted on the inner surface. On the other hand, consumers still hold the bottle with the same force. It means that the force exerted on the outer surface is not changed. As a result, the bottle is crushed by the external force exerted by consumers' hands (Boukobza & Guen, 2004).

To remedy the deformation of the plastic bottle for the carbonated beverage after it is open, a curve groove is proposed to integrate to the body of the plastic bottle as one large rib. This large rib provides the support when the bottle is open. The structure of the large rib needs to be configured carefully to avoid a susceptible part which is easy to be deformed by the internal pressure when the bottle is filled with a carbonated beverage. The proposed design feature for the bottle used to contain the carbonated beverage can be seen in Figure 11 (Boukobza & Guen, 2004).

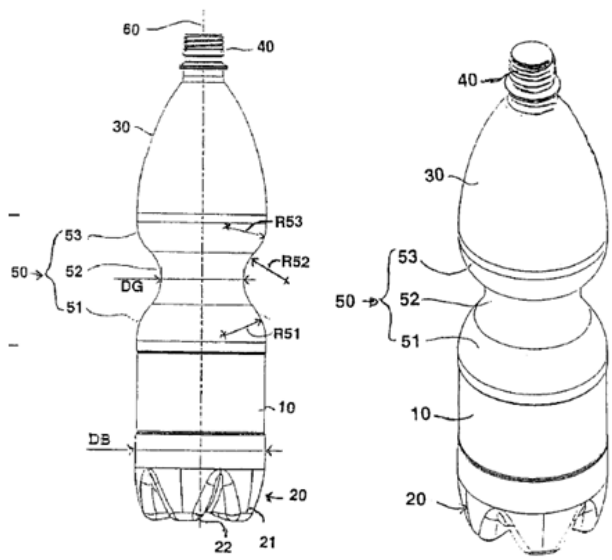

Figure 11: Plastic bottle with a curve groove for a carbonated beverage (Boukobza & Guen, 2004)

3.1.3 General beverage industry

Nowadays, the secondary packaging has gradually been reduced. For instance, the whole paperboard box is replaced by a carton tray with a wrapping film. This reduction creates more stress on plastic bottles which are contained inside secondary packaging. Therefore, plastic bottles require the better structure to suffer stress. In addition, the plastic packaging industry always has interest in developing the lightest possible packaging to achieve an aesthetic appearance, environmental sustainability, and cost optimization in the whole supply chain (Hanan and Peykoff, 2013). Thus, there are more and more varieties of ribs designed and applied to plastic bottles for both increasing mechanical performance of the bottles and creating the lightest bottles at the same time. According to Hanan and Peykoff (2013), the application of varying depth ribs smoothly transitioned around the bottle body supports to the balance of strength and rigidity. At the same time, it can reduce raw materials for plastic bottles. Finally, a lightweight bottle with a combination of varieties of ribs is not only able to resist to blending, leaning, stretching, but supports the recognition of a product brand on retailers' shelves and tight fits on consumers' hands as well.

3.2 Value of rib designs on commercial plastic bottles

Even if the root cause of rib's applications on plastic bottles is to prevent the deformation, the rib design also carries other functions including technical, economic, environmental, marketing and convenience for consumers (Islem, 2013) as shown in Figure 12.

Figure 12: Five pillars of Packaging design (Islem, 2013)

To gain in-depth understanding of rib's functions, varying rib designs on some commercial plastic bottles are assessed and their functions are grouped into three main categories which are (1) technical and economic functions, (2) marketing and convenience functions, and (3) environmental functions. In addition, some disadvantages of ribs on plastic bottles are also evaluated in the following part by assessing one example of a rib-less plastic bottle.

3.2.1 Technical and economic functions

3.2.1.1 APPE PET hot filled bottle with horizontal ribs

The rib design feature of APPE Company from the UK is one typical example of ribs which are applied to prevent the deformation of hot filled plastic bottles, as shown in Figure 13. This design includes many horizontal ribs integrated on the body to provide additional rigidity to the hot filled bottle with the high filling temperature, up to 85°C. Thanks to the ability to contract after cooling and absorb the vacuum inside, these horizontal ribs help to counteract pressure caused by the filling and cooling processes (Packagingbuzz, 2013).

Figure 13: APPE PET hot filled bottle (Packagingbuzz, 2013)

Moreover, these ribs also contribute to increase top load strength and prevent the deformation during shelf life. Consequently, APPE can reduce packaging materials to produce the bottle with same rigidity. The PET bottle with these horizontal ribs is lighter, by 30% and packaging cost is also cheaper (Packagingbuzz, 2013).

However, these ribs are hidden behind a label. Thus, the ribs in this design do not create brand differentiation or add aesthetic attribute for the bottle. Indeed, with this design, APPE needs to apply sufficient numbers of ribs to ensure the smooth and adhesive surface for facilitating the labelling process afterward. (Packagingbuzz, 2013).

The rib design applied to APPE PET bottle is quite similar to the one developed by Rashid 2001. In his design, some parameters of ribs' configuration to fulfil functions of preventing deformation and facilitating a labelling process are described. In detail, the ratio of the depth (C) to the width (E) of each rib is in a range of 1.0:1.0-1.1:1.0 and the ratio of the average land width (30) to total rib width (26) is in a range of 1.09:1.0-1.3:1.0. This rib configuration can reduce the deformation of the bottle during the hot filling process and it also optimizes the strength of the label panel section (24) as illustrated in Figure 14 (Rashid, 2001).

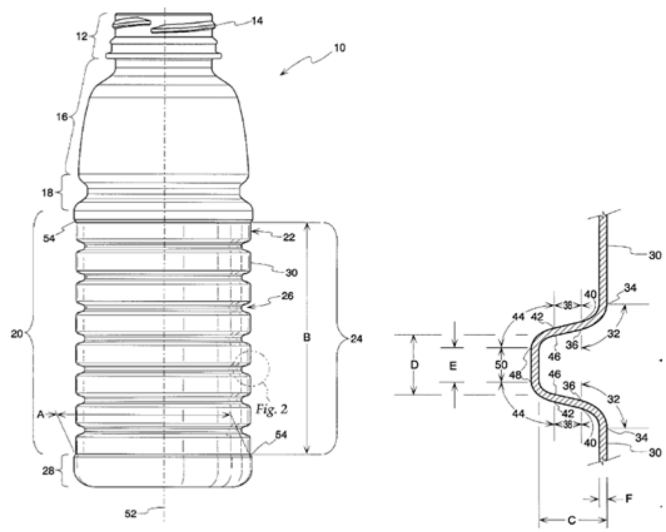

Figure 14: A- The rib-shaped bottle (left), B- Cross sectional view of a single rib 26 (right) (Rashid, 2001)

3.2.1.2 *Arizona PET hot filled bottle with horizontal ribs*

Another design of horizontal ribs configured to take up vacuum and prevent deformation is the one of Arizona, as seen in Figure 15. In this design, horizontal ribs are integrated with a ball shape and three customized vacuum panels to fulfil this mission. Basically, this design is similar with the rib design of APPE, except a ball shape to increase top load strength and three vacuum panels to enhance the removal of vacuum inside of the bottle. Moreover, these ribs are not hidden behind a shrink label, thus packaging designers do not need to consider carefully about the ribs' configuration for the label. In terms of convenience, these ribs incorporated with vacuum panels provide an easy grip feature for consumers. In addition, these ribs and three embossed panels with Arizona brand name in the vertical orientation are visible for reinforcing the company brand (Steeman, 2009).

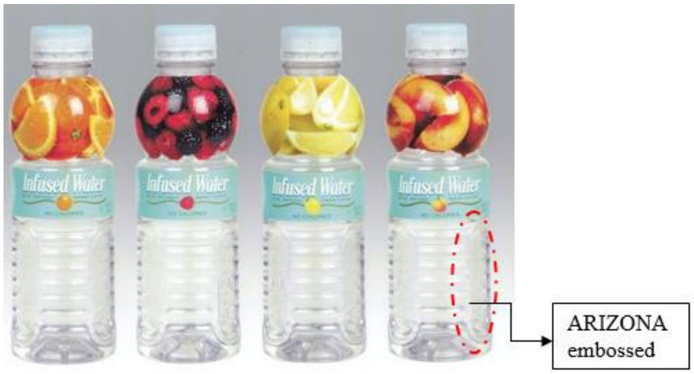

Figure 15: Arizona hot-filled bottle with ribs and panels

3.2.1.3 PP sterilized plastic jar with horizontal ribs

In terms of material, beside PET, ribs can be applied to PP containers. Two examples are the RPC Corby's 1-litre ultra-multilayer PP jar for puree products and the PP bottle of Graham Packaging Co., York as shown in Figure 16– A and B respectively (RPC 2003, RPC 2005, GrahamPackaging, 2004).

Figure 16: A-RPC Corby's 1-litre PP jar (left), B- PP bottle of Graham Packaging (RPC 2003, RPC 2005, GrahamPackaging, 2004)

Ribs applied to PP containers also help to prevent the distortion which is caused by the high temperature of the pasteurisation or the sterilisation condition, up to 93.34°C. Besides this function, ribs do not support for other functions related to economic or consumer convenience aspect. (Grande, J. A., 2007).

3.2.1.4 Coca Cola PET warm filled bottle with geometry ribs

Besides horizontal features, other rib designs also carry some technical functions which are not related to preventing distortion. An example is the Coca Cola shallow rib-shaped plastic bottle that won the 2013 Australian Packaging Design Award, as shown in Figure 17.

In this design, ribs provide a technical function in the weight reduction. In detail, ribs help to reduce the bottle weight from 33 grams to 24 grams (by 27.3%) and make this bottle become the lightest bottle among other similar one for the same product appearance. However, this rib design leads to the changing in the filling process, from hot filling to warm filling (Lopez P., 2014). This implies that these shallow ribs do not create as good impact on reducing distortion as those horizontal ones do. Although these ribs do not work well in reducing deformation, they save substantially energy consumption for the filling process.

Figure 17: Coca Cola bottles with shallow geometry ribs (Lopez P., 2014)

In terms of marketing, this rib design improves significantly the visual appearance of the bottle (Lopez P., 2014). Thus, in this design, the ribs have three functions which are reducing packaging materials, reducing production energy, and differentiating the product brand.

In general, some designs of ribs on commercial plastic bottles showed clearly two technical advantages of ribs in preventing deformation or/and reducing packaging material. In addition, ribs also carry other functions in enhancing convenience for consumers and create brand differentiation.

3.2.2 Marketing and convenience functions

3.2.2.1 Powerade PET bottle with geometry ribs

Nowadays, the competition in the food industry is growing more than ever before. Consequently, food and packaging companies need to focus more on consumer convenience and brand differentiation to create the competitive capability on the market. Colin Jones, the vice-president sales & marketing, Global Closure Systems said:

"Convenience is king in many consumer products. By making a product easy to use, consumer companies have a differentiator to attract consumers" (Stephen, M. 2006)

In order to provide convenience for consumers, packaging contributes an important part. Among many ways to fulfil this mission, incorporating ribs and panels into packaging is one effective way to achieve both the visualisation of brand and consumer convenience. Two packages of a sport drink product Powerade of Coca Cola North America as seen in Figure 18 are the typical examples which show these functions of ribs.

www.pinterest.com

Figure 18: Powerade bottles with rib configurations for marketing and convenience functions

In these hot filled PET bottles, Coca Cola North American still designs ribs and panels to take up vacuum when the product cools down after a hot filling process but in an innovative way. The ribs are designed to be easy to grip and to fit tightly on consumer hands. Therefore, it helps to prevent bottles from slipping during usage. Furthermore, the geometry ribs and Powerade embossed on panels achieve aesthetic requirement which appeals consumers among other similar products on store shelves (Grande, J. A. 2005).

3.2.2.2 Volksbier glass-can-shaped beer packaging with geometry ribs

Another example of embossed ribs on a plastic bottle to create a premium image which makes a brand stand out at the point of sales is the glass-can-shaped beer packaging of Volksbier. This design as seen in Figure 19 won a 2014 Gold Pentaward in London for beverage packaging concepts. In this design, ribs are assembly geometrically to create a polyhedral wall and thanks to the transparency of PET materials, this packaging can stimulate glass effect (Ludacer, 2014). From combining two increasing trends in the beer market: PET and can packaging, this design creates a distinctive shape to differentiate product, maximize on-shelf appeal, as well as establish the brand identity.

Figure 19: Volksbier glass-shaped beer packaging designed by Remark Studio (Ludacer, 2014)

3.2.3 Environmental functions

3.2.3.1 Sidel PET bottle with geometry ribs

In recent years, environmental sustainability has an increasing role on packaging design because of the stricter environmental legislations and the higher consciousness of consumers. In most of countries, governments have established rules about the responsibility of packaging producers with regards to environmental impacts during the product life cycle. These legislation frames usually insist on the reduction of packaging materials and negative impacts on the environment throughout the whole supply chain. Moreover, the raising of the global environmental issues such as global warming effect is alerting consumers about their role in choosing products of companies who take responsibilities for the environment. Nowadays, consumers and customers are put in the centre of most companies' product development and innovation activities (Moskowitz et al., 2012). As a result, both food and packaging companies need to consider carefully the environmental aspect in their packaging design.

Sidel is not an exceptional case among these companies. Motivated by this trend, Sidel developed the rib shaped bottle Sidel's StarLite and won the title of "The Best Environmental Sustainability Initiative" at the Global Bottled Water Awards in 2013. The ribs applied to this bottle, in combination with the shape, help to optimize the resistance and stability of the bottle base, as well as improve the rigidity of the overall bottle (Packagingbuzz, 2014).

Figure 20: Sidel bottle for sustainable environment (Sidel, 2014)

The rib design of Sidel as shown in Figure 20 enables the company to cut the amount of raw materials and packaging cost. In particular, the new bottle weighs 34% less than an average commercial bottle and achieves 32% more top-load performance than the lightest commercial bottle on the market**.** This design at the same time benefits Sidel in cost saving of EUR 1.75 million per year while still keeping the protection function of this packaging.

Besides, the increased resistance of this bottle helps to enhance consumer experience. For instance, it eliminates the 'over squeeze' issue and prevents the spilling of content accidentally. The higher resistance of the bottle also helps to protect its appearance during the supply chain (Sidel, 2014). Thus, the Sidel bottle can deliver more attractive appearance to consumer.

The impact of ribs on the Sidel bottle is not only in cost reduction and user-friendliness but also in reducing environmental impact on every step through the whole supply chain. Less materials used for the Sidel bottle leads to less environmental impact from material production, transportation, and the recycling process. In addition, the Sidel bottle design can achieve high top load without the assistance of nitrogen (Sidel, 2014). Thanks to that, it helps to reduce further cost and save energy as well as decrease environmental impact.

3.2.3.2 Coca cola block bottle with horizontal ribs

Another design of ribs particularly focusing on the reduction of environmental impact is the Coca Cola block bottle. The ribs are designed underneath the label, so that they do not have any effects on branding as illustrated in Figure 21. These ribs make the bottle be compressible like an accordion after being emptied. Thanks to that, the bottle takes up less space when it goes into the recycling truck (Thedieline, 2010). As a result, the transportation cost and the negative environmental impact of the recycling process are reduced.

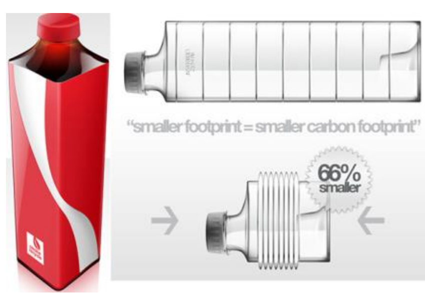

Figure 21: Coca Cola block bottle with ribs to reduce environmental impact (Thedieline, 2010)

These designed features of ribs on Sidel and Coca Cola bottles illustrate another function of ribs. It is the ability to reduce the environmental impact, by reducing raw packaging materials or space during the recycling stage at the end of the product life cycle.

3.2.4 Disadvantage of ribs on plastic bottles

3.2.4.1 PowerFlex panel-less, rib-less PET bottle

As presented above, ribs have many functions in packaging design, including technical, economic, environmental, marketing, and convenience ones. However, is a design feature with a lot of ribs incorporated in packaging good in all cases? This question is answered by the commercial rib-less, panel-less PET bottle (PowerFlex) of Amcor for 473ml ready-to-drink tea for Tradewinds Beverage Co., in September, 2008.

Based on many careful researches, Amcor found that even though ribs help to prevent the deformation of bottles' wall, a lot of ribs create an inverted affection due to some disadvantages of ribs' application. With a lot of annular ribs on the bottle body, the surface of the bottle body is not smooth, thus a label is easy to be wrinkled or damaged before reaching consumers. Consequently, the label cannot support promoting the product and its brand (Amcor, 2005). Furthermore, the configuration of too many ribs will increase cost of the bottle due to the complexity of the mould needs to be produced (Rashid 2001).

Therefore, Amcor invented the PowerFlex bottle with rib less and an inverted cone-shaped design as shown in Figure 22. For this feature, vacuum distortion occurs only in the base but an inverted conical diaphragm (as red line in the Figure 22) will subside it. In addition, the base is thicker with a larger diameter with respect to the bottle diameter, compared to the base of the bottle with many ribs. As a result, the vacuum is removed and there is no potential for bending or distortion (Hanan & Peykoff 2013, Stephen M. 2004).

Besides the main functions like absorbing distortion or eliminating label crinkling, the panel less design also helps to reduce the weight of the PET bottle as Joseph A Grande. With these strong points, Graham Packaging is confident that the rib-less PowerFlex bottle can lay down challenge to glass (Stephen, M. 2004). The glass feeling of this bottle can create the premium image for the product, thus it facilitates the consumption.

Figure 22: Rib-less panel-less PET bottle of Amcor

The design of Amcor proved that ribs need to be applied with sufficient numbers on packaging to take advantage of their functions and limit their disadvantages. With the sufficient numbers, the ribs and panels can fulfil their main mission without hindering the labelling process, especially create the aesthetic appearance for bottles and promote brand.

In conclusion, rib designs applied to plastic bottles have both advantages and disadvantages. The important advantages of rib designs on plastic bottles are the technical functions which are reducing distortion, packaging materials, and packaging weight. Thanks to that, rib designs indirectly help to optimize cost, increase production efficiency, and reduce environmental impact of plastic bottles. Moreover, rib designs also support consumer convenience, enhance the aesthetic appearance of packaging, and build brand differentiation. However, rib designs might carry some disadvantages which are hindering the labelling process and higher cost for making complex moulds. Therefore, ribs should be designed with careful consideration of these drawbacks to benefit all rib' functions.

3.3 Background of ribs' applications on metal cans

Besides plastic bottles, metal cans are very popular ribbed packages which have been used for a long time on a wide variety of products, including processed, non-processed food and beverage. These packages can be categorized into two types depending on their designs. Two main types of cans are three-piece cans and two-piece cans as seen in Figure 23.

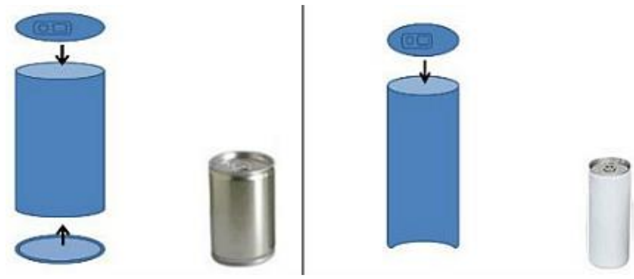

Figure 23: Three-piece can (Left) and Two-piece can (right)

In both types of cans, there is always a demand to reduce the thickness of cans' body as much as possible in order to reduce packaging materials, packaging cost, and weight of cans (Ishinabe et al., 1992). Reducing the packaging materials and the weight of cans also lead to the reduction of transportation cost and negative environmental impacts, similarly to the case of plastic bottles. However, the mechanical strength of the cans is decreased as well. Accordingly, the cans easily suffer deformation by collision during the operation processes or by pressures during the shelf life of products. Once the deformation appears, inner and outer protecting coating layers of the metal sheets used to make the cans may have some coating defects such as corrosion, cracks, or leakage trouble (Ishinabe et al., 1992). Therefore, ribs are applied to metal cans either in the circumferential direction or in the axial direction to enhance the resistance against deformation and protect the original appearance of cans.

3.3.1 Three-piece cans

A three-piece can is designed to utilize a metal sheet which is preferably made of electrolytic tin plate (ETP), chrome-plated steel and/or tin free steel (TFS) (Canadian Food Inspection Agency, 2012). It is created by "forming metal sheet into a cylindrical shape, joining confronting edge portions by welding, bonding, or soldering to form a can barrel having a side seam, and thereafter wrapping seaming both the ends of the can barrel with top and bottom lids" (Ishinabe et al., 1992). Figure 24 illustrates one example of the three-piece can with side seam, body bead, and canner end which has already covered by the top lid. The body bead is designed by "rib-like indentations on the can body located singly or in clusters on the general body area to provide resistance to lateral abuse (denting)" (Canadian Food Inspection Agency, 2012).

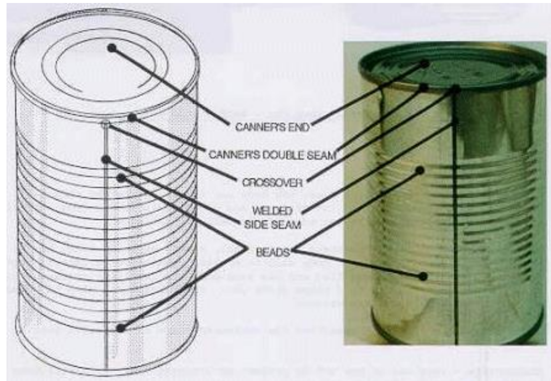

Figure 24: Three Piece Can Bodies - Welded Side Seam (Canadian Food Inspection Agency, 2012)

According to Cooper (1936), the conventional cylindrical can body is not susceptible of withstanding excessive forces or external pressures without distortion of its appearance. Thus, he invented internal corrugations, ribs or embossments formed in the wall of the cylindrical can. Figure 25 shows some initial forms of rib designs which were introduced by Cooper (1936). Thanks to these ribs, the body of the can has a greater resistance to the expansion, contraction or partial vacuum pressure from the sterilisation process. Accordingly, these ribs help to: (1) stiffen and strengthen cans' body against deformation, (2) give the possibility for a lighter weight can, and (3) not interfere with the labelling and seaming operations in the can manufacturing (Cooper, C.R., 1936).

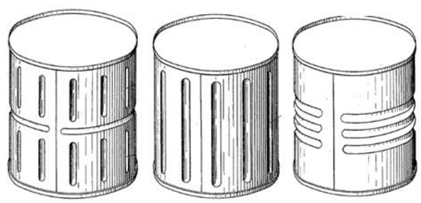

Figure 25: Some three piece metal cans with ribs (Cooper, C.R., 1936)

After Cooper, Swanson et al. (1976) figured out that the additional of four horizontal reinforcing ribs with the axial width of each rib about one thirty-fifth of the length of a can helps to add an increase of 58% in the rigidity without increasing the overall wall thickness of the can. Thanks to that, the can has a better resistance against pressure.

Nowadays, the three-piece cans are used widely for food stuffs and normally go through the sterilisation process in the continuous autoclave after seaming products. The modern sterilized equipment is different from other equipment in the past, but the cans still suffer from pressures caused by the process. Besides, the cans also suffer from stacking pressure during the storage and transportation stage. However, the pressures which cause the main deformation of the cans in almost all cases are the expansion, contraction, and partial vacuum pressures from the sterilisation process. In order to prevent the deformation, radial strength and hoop strength of the cans are necessary to be enhanced (Takahara & Santos, 2012). The direction of radial and hoop stress can be seen in Figure 26. Thus, horizontal circular ribs are added around the peripheral, top and bottom lids of the can as seen in Figure 27.

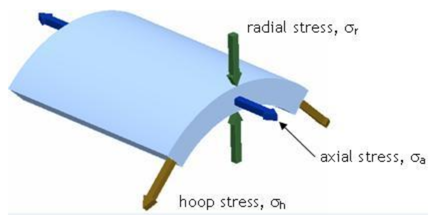

Figure 26: Direction of 3 main stress on cylindrical surface (Burst and Collapse, 2015)

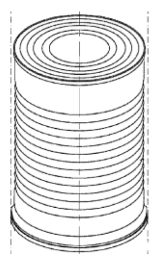

Figure 27: Three-piece cans with ribs on the body and the lids (Swanson et al., 1976)

3.3.2 Two-piece cans

The second type of metal cans is a two-piece can which varies in shape and used materials. Major materials used for two-piece cans are aluminium and tin-plated steels. The two-piece can is formed by deep-drawing or ironing the metal sheet into a bottomed can barrel and wrap-seaming the top end of the bottomed can barrel with a lid (Ishinabe et al., 1992). Figure 28 and Figure 29 illustrate two examples of two-piece cans used for food products.

The two-piece can in Figure 28 is designed with a side bead and panel steps which are actually ribs, in an integral end. The purposes of ribs here are (1) providing resistance to distortion caused by pressures during the sterilization process, (2) assisting stacking, and (3) supporting the sterilisation process by the rolling characteristic (Canadian Food Inspection Agency, 2012).

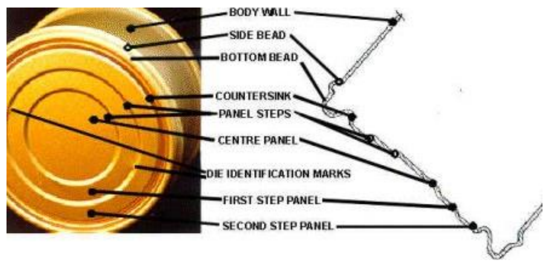

Figure 28: Integral End of a round two-piece can (Canadian Food Inspection Agency, 2012)

Besides, a series of ribs under the form of rings or parallel lines are pressed into any parts of the can body or integral end as seen in Figure 29 for providing additional strength to withstand the stresses of retorting and handling (Canadian Food Inspection Agency, 2012).

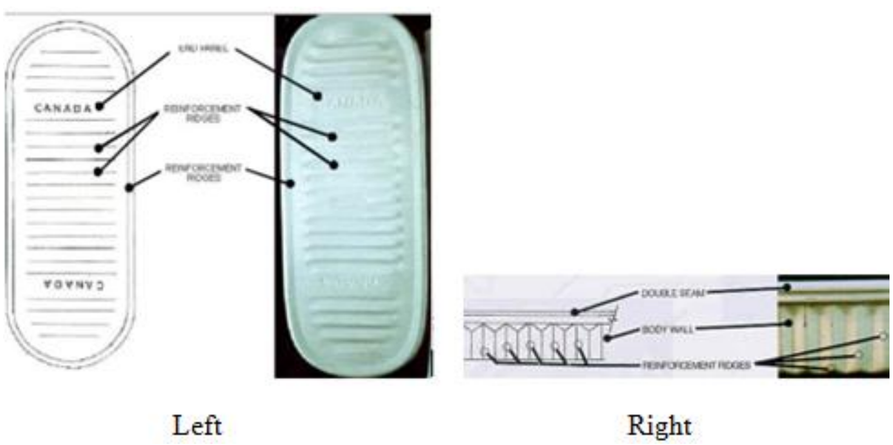

Figure 29: Integral End (Left) and Body (Right) of a non-round two-piece Can (Canadian Food Inspection Agency, 2012)

The two-piece can is also designed in another form which is applied for beverage products such as beer, soft drink, or ready-to-drink tea as seen in Figure 30. This form of the two-piece can is not necessary to go through the sterilisation process; however, there may have deformation which is mainly caused by axial stress from the seaming operation or the stacking process during storage or transportation (Shore et al., 1999). The direction of axial stress on the can is shown in Figure 26 above. To protect the can from the deformation by this stress, ribs are applied to the can body in vertical direction as seen in Figure 30. A plurality of parallel longitudinal ribs which are equally spaced around the circumference and terminate within the zones 7-8 on the side wall improve the axial strength for the can. Thanks to that, the rigidity of the can is enhanced and the thickness of the can's wall has the possibility to be reduced (Claydon, 1993).

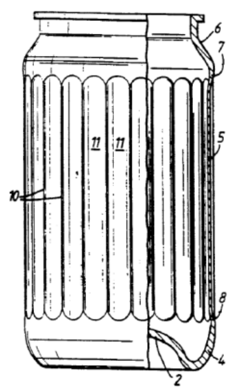

Figure 30: Two-pieces can with vertical ribs (Claydon, 1993)

Besides rib configurations which are arranged either longitudinally or horizontally, there is another rib design which is the combination of both direction. Shore et al. (1999) indicated that the irregular shape can should integrate with ribs that are arranged both longitudinally and circumferentially or helically to impart the additional strength to the can body. Two main reasons are (1) the shaping process for making stylized design places a great strain on the can body and (2) any deviation from a cylindrical shape can reduces the axial strength of the can. Consequently, the irregular shaped can is more susceptible than the straight can toward other pressures, such as internal pressure caused by carbonation. Thus, Shore et al. (1999) proposed the sidewall portion that integrates a plurality of circumferentially extending ribs with a substantial number of longitudinally extending ribs to provide both hoop strength, radial strength against expansion due to internal pressure and vertical crush strength (axial) for the can body, as seen in Figure 31. This rib design will help to strengthen some weak positions which are susceptible to the deformation on the can body. For instance, a can with a wall thickness of 0.104 mm integrates horizontal and vertical ribs with a thickness from 0.025 to 0.051 mm at the locations that are intended to be reinforced. Consequently, the thickness at these locations is about 0.127 to 0.152 mm. By this way, the can is well pressure tolerant (Shore et al., 1999).

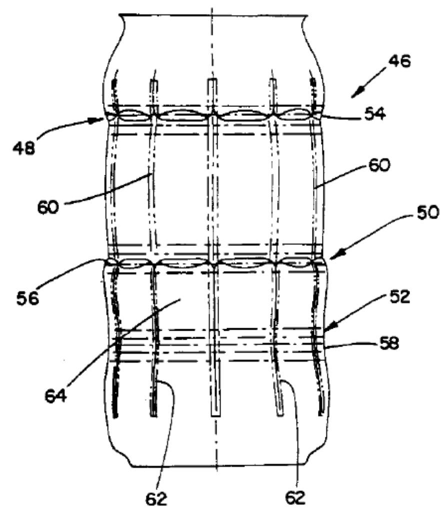

Figure 31: A shaped can with integrated ribs circumferentially and longitudinally (Shore et al., 1999)

3.4 Value of rib designs on commercial metal cans

Similarly to the case of plastic bottles, various rib designs on some commercial metal cans will be assessed to get in-depth understanding about the value of ribs on this packaging. The commercial ribbed cans are grouped into three main categories depending on ribs' functions, which are (1) technical and economic functions, (2) marketing and convenience functions, and (3) environmental functions.

3.4.1 Technical and economic functions

As presented above, in both types of cans, ribs are integrated on the cans' body or integral ends to fulfil the main mission in enhancing mechanical strength of cans, including axial, radial, and hoop strength. Thanks to that, ribs give the possibility to reduce the packaging cost, transportation cost as well as cost from damage products. In addition, rib designs also assist the stacking of cans on top of each other and support for the sterilisation process by providing the rolling characteristic. Accordingly, rib designs contribute to increase the capability of cans' production and transportation.

Besides, it should be noted that three-piece cans are more cost-sensitive than two-piece ones. Because the material utilisation of three-piece cans is better than the one of two-piece cans. Moreover, Bradley (2005) pointed out that the cost to set up a two-piece can line is about $20-25 million per line while the cost for building a three-piece can line is much cheaper, around $8.5-9 million per line. Thus, companies using three-piece cans usually employ cheap label solution which is a printed paper label covering the cans' body instead of printing product information directly on cans. The ribs covered by labels are seen in Figure 32. Consequently, the rib feature on three-piece cans is designed as simple horizontal annular rings to fulfil only technical and economic functions.

Figure 32: Commercial three-piece cans with ribs hidden by labels

However, when the ribs on three-piece cans are hidden under labels, they create an uneven surface which affects to labels, similarly to the case of plastic bottles. As a result, the aesthetic appearance of these cans is affected and the risk of label distortion is higher.

Besides, Ishinabe et al. (1992) pointed out that the maximum strength increase of these ribbing cans against the deformation caused by external pressures is just about two times, as compared to cans without ribs. Accordingly, the strength increase does not achieve the requirement in some cases. Therefore, a reinforcing rib structure with circumferential polyhedral wall designed on a can body was invented, as seen in Figure 33. The polyhedral wall has many structural unit faces as seen in Figure 34. These unit faces are curved to the inside surface of the can and arranged in the way that adjacent rows (illustrated by two red lines on Figure 33) of unit faces have a phase difference in the vertical direction (illustrated by a blue arrow on Figure 33) of the can. Thanks to this configuration of ribs, the can body has the higher strength against the deformation by external pressures. When each unit has the L/W (length/width) ratio from 0.2 to 4.0 and the d/do ratio from 0.5 to 2, as illustrated in Figure 34, the resistance against external pressures achieves the highest value. The appearance of the printed surface can also be guaranteed (Ishinabe et al., 1992).

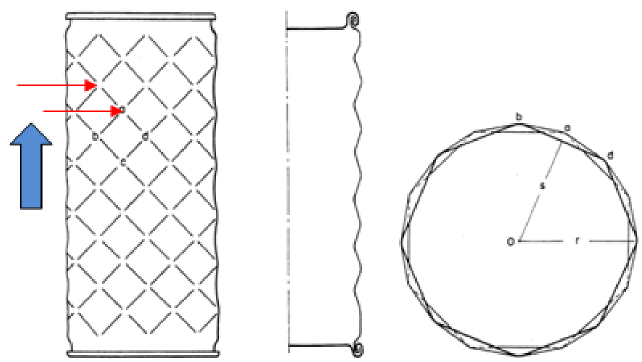

Figure 33: A reinforcing rib structure with circumferential polyhedral wall (Ishinabe et al., 1992)

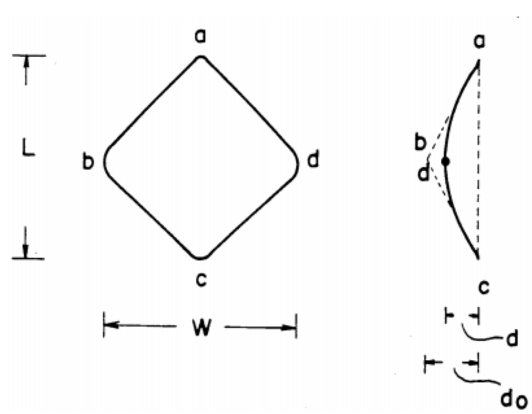

Figure 34: One structural unit face of the circumferential polyhedral wall (Ishinabe et al., 1992)

Besides, this circumferential polyhedral wall is not necessary to be constructed on the entire surface of the can as seen in Figure 33. Indeed, when more than 10% area of the entire can's surface is covered by this rib feature, especially at the central part of the can, the sufficient prevention from the deformation can be achieved. Furthermore, in case of tetragonal structural unit faces, the number of the structural units is recommended from 4 to 12. For hexagonal structural unit faces, the number of the units should be from 3 to 10. These rib parameters can be applied to both two-piece cans and three-piece cans with the similar effect in increasing the rigidity of the can body (Ishinabe et al., 1992).

3.4.2 Marketing and convenience functions

Besides technical and economic functions, marketing and convenience functions are also reasons for applying ribs to metal cans. The can with the circumferential polyhedral wall formed by ribs as seen in Figure 33 is a typical example for a marketing function (Ishinabe et al., 1992). This design feature of ribs has a more attractive appearance than a conventional straight cylindrical can. Ishinabe and his colleagues (1992) also proposed other similar designs of ribs which can be seen in Figure 35 to enhance the aesthetic appearance of cans. These designs still have the technical functions, similarly to the design in Figure 33.

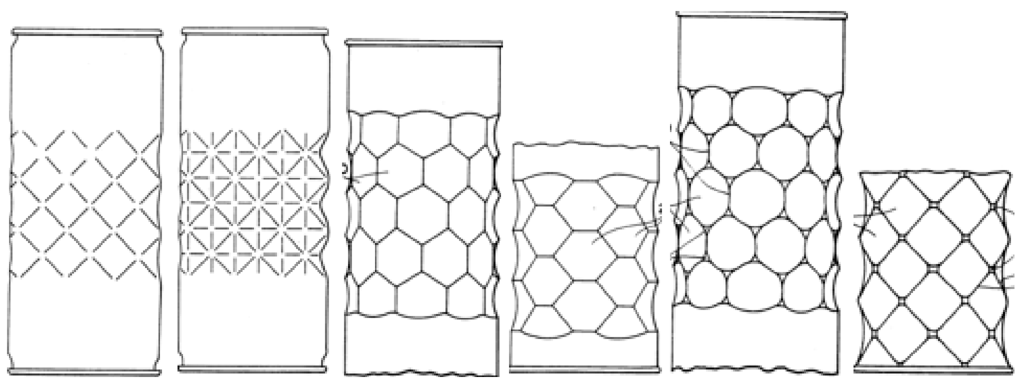

Figure 35: Some circumferential polyhedral walls design with ribs for mechanical strength (Ishinabe et al., 1992)

Thanks to the marketing function, the designs of Ishinabe et al. (1992) are applied to many commercial cans for brand identification and consumer attraction at the point of sales. One example is the “Fire” canned coffee as seen in Figure 36 launched by Kirin Company, Japan in 2001.

Figure 36: Fire Canned Coffee of Kirin made of ribs (Pete Drinks, 2012)

As presented above, ribs on three-piece cans do not have any marketing function because they are hidden under labels. However, for two-piece cans, the ribs are visible as seen in Figure 37. In these case, companies usually employ the ribs as one of their tools in order to shape brand differentiation.

Figure 37: Commercial two-piece cans (Pete Drinks, 2012)

Indeed, the marketing function of ribs on cans was shown clearly by the Coca Cola contour can in 1997. To resemble their traditional trademark glass bottle, Coca Cola churned out the contour aluminium can as seen in Figure 38.

Figure 38: The "contour can" of Coca Cola (Beach packaging design, 1998)

The ribs designed on the contour can did not provide any technical function; however, this design boosted sales of this stock keeping unit (SKU) as much as 90% in some areas when the price of this contour can was kept similarly to the conventional Coca Cola can (Beach packaging design, 1998). According to a Coca Cola officer, consumer research on this aluminium can showed that consumers liked this design, but they were not willing to pay more for it. Therefore, Coca Cola could not increase the product price, even 10% to reimburse the costs from the new production line and transportation. However, the contours on the Coca Cola can certainly showed the beneficial of ribs in appealing consumers, preventing counterfeiters, and enduring a unique image of Coca Cola in consumers' minds (Beach packaging design, 1998). The Coca Cola can actually belongs to the group of shaped cans that are mentioned by Shore et al. (1999) above. The ribs on shaped cans according to Shore et al. (1999) carry some technical functions but the design of Coca Cola contour can had not inherited yet.

In terms of consumer convenience, similarly to plastic bottles, ribs may help consumers to hold easily cans in their hands. However, this function is not significant because normally cans have small size and are easy to handle.

In general, in terms of marketing and convenience functions, ribs on metal cans support creating product differentiation, attracting consumers, shaping brand, and preventing the counterfeit. However, companies need to consider carefully about the configuration of ribs to achieve the best appearance and at the same time keep the minimum initial investment.

3.4.3 Environmental functions

As aforementioned, when incorporating ribs on cans, ribs help to enhance rigidity of cans, decrease thickness, and reduce packaging materials. These technical functions of ribs affect directly on the environment. In detail, less metal materials for can making lead to lower resource, energy consumption, and emissions from metal production and from recycling or disposing processes. Furthermore, the reduction of can weight and the improvement of stacking property thanks to ribs help to increase the number of cans per shipping. Thus, rib designs help to decrease greenhouse gas emissions from transportation. The rigidity structure of ribbing cans also helps to reduce food waste and its impact throughout the supply chain.

Besides, there is another way to reduce negative environmental impact of cans at the end of the product life cycle. It is the collapsible design that makes the can body able to reduce the volume after being emptied, as seen in Figure 39. Thanks to the incorporation of ribs on the can body, more cans are contained in recycling containers. Consequently, the disposing stage takes less energy and cost (Inewidea, 2011). From consumer perspective, the ribs on cans also provide convenience function because these emptied cans take less space inside consumers' waste baskets at home.

Figure 39: Handy collapsible can concept (Inewidea, 2011)

Indeed, the circumferential polyhedral wall made by ribs on the can body of Ishinabe et al. (1992) is also one design of collapsible cans. Thanks to this structure, the can is folded or squeezed easily after open as seen in Figure 40.

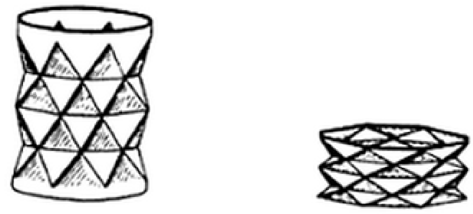

Figure 40: Collapsing mode of the can with circumferential polyhedral wall (Ishinabe et al., 1992)

In conclusion, ribs applied to metal cans have both advantages and disadvantages but the former surpasses the latter. Originated from the demand of material and cost reduction, ribs are designed on cans and lead to many other advantages. Firstly, ribs provide technical functions, including preventing deformation caused by external pressures as well as reducing packaging materials and packaging weight. Based on that, it leads to the cost advantage by optimising costs from packaging materials, production, and transportation. Secondly, rib designs provide aesthetic attributes for brand differentiation, consumer attraction, and preventing the copying from competitors. Lastly, ribs help to reduce negative environmental impact thanks to less materials usage and collapsible property of ribbing cans after use. However, ribs have some disadvantages such as creating an uneven surface for label application and increasing initial investment for changing a production line. Applying ribs to create shaped cans also causes potential difficulties from non-standard stacking. Therefore, when applying ribs to metal cans, companies should carefully consider the rib design for inheriting all ribs' advantages and preventing disadvantages from the investment cost, the label application, and the stacking process of metal cans.

3.5 Value of rib designs on carton packaging

Rib is the design feature which is not only applied to plastic bottles and metal cans but also used in carton packaging. Two typical examples are a wrapping carton around a cup for hot vending coffee and an egg carton packaging.

For the wrapping carton around a coffee cup, as seen in Figure 41, ribs show a completely different function compared to these aforementioned functions. The main function of ribs in this application is increasing thermal insulation. Thanks to the trapped air between these ribs, the amount of heat transmitted from the cup to consumers' fingers is reduced (Han et al., 2005).

Figure 41: Detpak hot vending coffee cup

For the egg carton packaging as seen in Figure 42, ribs are integrated on the carton container for the reinforcement functions. A plurality of hollow partitioning ribs (45-2) which are integrated with a number of transverse ribs (35-2) is formed on a top surface of a cover. In addition, the transverse ribs are also created on the back of the top surface (35-1). Thanks to that, when a number of loaded cartons is stacked one on top another, the cover is strong enough to prevent from bending or distortion longitudinally. At the same time, these ribs support to strengthen the latch of the egg carton in order to help the cover panel not to spread outwardly (Alroy 1973).

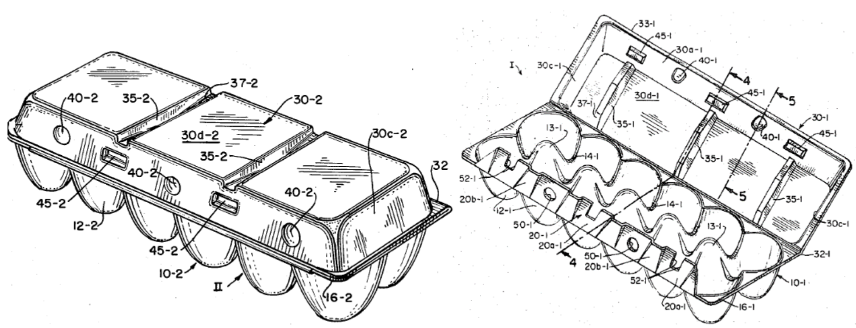

Figure 42: Egg carton container with reinforcing ribs (Alroy 1973)

In addition, ribs (11) as seen in Figure 43 are embossed on each compartment in order to shape the non-planar surfaces in the plurality of compartments at the bottom part of the egg carton container. Thus, these compartments have shapes which match partially the outer contour of eggs. Accordingly, the egg contained inside each compartment is stable and prevented from breaking during transportation (Alroy 1973, Wade 1964).

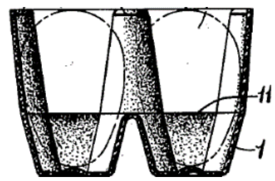

Figure 43: Two compartments of egg carton packaging are shaped by ribs (Wade 1964)

3.6 Value of rib designs on food packaging

In summary, the literature review provides the holistic picture of the functions of ribs on plastic bottles, metal cans, and food packaging in general. The functions of ribs mentioned here consist of many aspects, including technical, economic, environmental, marketing, and convenience. The technical functions of ribs' applications on food packaging in general include (1) preventing deformation caused by the sterilisation process or external pressures, (2) increasing top load strength for the seaming and stacking processes, (3) enhancing resistance to bending, (4) reducing packaging materials and packaging weight, (5) protecting coating layers from cracks, corrosion, leakage, (6) assisting the sterilisation process, (7) creating thermal insulation, and (8) maintaining the standard appearance of product until the consumption stage. Regarding economic functions, the applications of rib design help to minimize costs thanks to less packaging materials, high production capacity and transportation efficiency, and less damaged products. In addition, the applications of rib design support reducing negative environmental impact. In particular, ribs' applications help to reduce natural resource usage, energy consumption, and emissions caused by the production and the recycling processes of packaging. In terms of marketing and consumer convenience, ribs' applications provide better aesthetic appearance for packaging. Thanks to that, ribs' applications support attracting consumers, enhancing consumption, and differentiating product brands as well as hindering counterfeiting.

However, the applications of rib design have some disadvantages such as creating an uneven surface for label application and high initial investment for changing production lines or making complex moulds. Applying ribs sometimes causes difficulties from non-standard stacking. Therefore, when applying ribs to packaging, companies should carefully consider the rib design for inheriting all ribs’ advantages and preventing their disadvantages.

The in-depth understanding of ribs’ functions on food packaging creates concrete fundamentals to develop the consumer research in the next stage in order to further answer the research questions mentioned in Chapter 1.

4 RESULTS AND DISCUSSION

This chapter describes the findings from the consumer studies conducted on the two different groups. The chapter includes three main parts: (1) results of the first consumer study, (2) results of the second consumer study, and (3) the comparison between the two studies and discussion on the perception of the researched Swedish consumers toward ribs and the driven criteria for their purchasing decision.

4.1 Results of the first consumer study

The first consumer study was carried out with the consumers of Group 1 in order to explore their perception toward ribs on plastic bottles, metal cans, and carton containers as well as the driven criteria for their purchasing decision. As mentioned in Chapter 2, the three investigated criteria are aesthetic appearance, convenience, and environmental friendliness of packaging.

4.1.1 Consumer perception toward ribs on metal cans

Firstly, the consumers were introduced to two metal cans: one with ribs (right) and one without ribs (left) as shown in Figure 44. Indeed, the can without ribs (left) has some ribs under the paper label. However, the ribs are very shallow and hidden, thus this can is considered as a non-ribbing can. Next, the consumers were asked to grab the cans and answer a question “Which metal can do you prefer when handling on your hand?”

Figure 44: The non-ribbing can (left) and the ribbing can (right)

As seen in Figure 45, 52% of the consumers preferred the ribbing can while 48% of the consumers preferred the non-ribbing can. The gap between the two proportions (52% and 48%) is not really large enough to conclude if the consumers of Group 1 really prefer ribs on metal cans, in terms of convenience during holding.

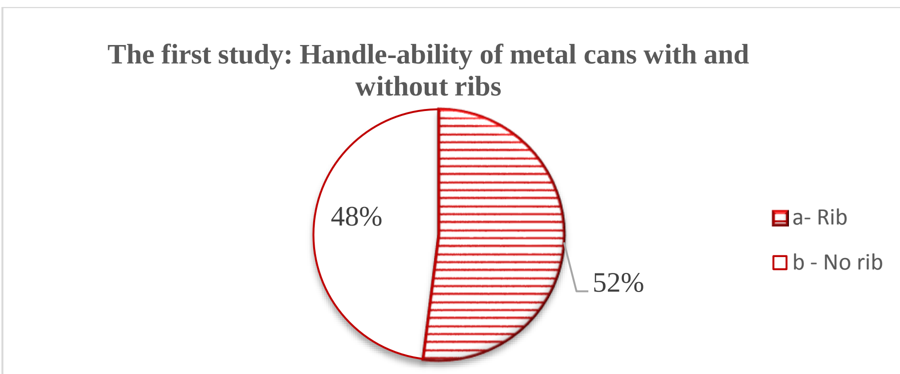

Figure 45: The first study- Handle-ability of metal cans with and without ribs

In addition, the consumers were asked to choose which can was easier for them to read product information. Up to 98% of the consumers chose quickly the non-ribbing can, as shown in Figure 46. This result shows that ribs completely hinder the readability product information in the consumer perception.

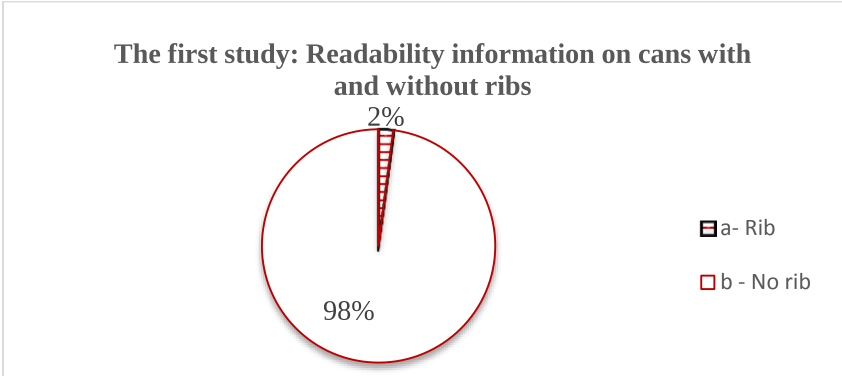

Figure 46: The first study- Readability information of cans with and without ribs

The results from the two questions show that in the perception of the consumers of Group 1, the ribs applied to metal cans do not provide any convenience functions for holding. Furthermore, the ribs reduce the readability product information on the body of cans.

4.1.2 Consumer perception toward ribs on plastic bottles

Regarding plastic bottles, the consumers were asked to select the most preferred one among three designs of plastic bottles based on visualization. The researched designs are (1) A- a bottle without ribs, (2) B- a bottle with horizontal ribs, and (3) C- a bottle with vertical ribs (vertical ribs are highlighted by red lines), as illustrated in Figure 47.

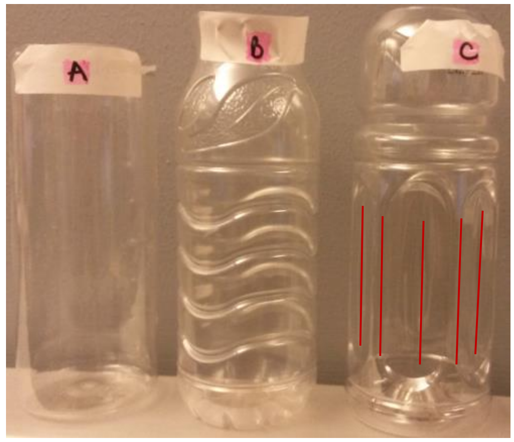

Figure 47: Three researched designs of plastic bottles

The result is shown in Figure 48. 98% of the consumers preferred the ribbing designs (B and C) while only 2% of the consumers preferred the non-ribbing design (A). Thus, it can be concluded certainly that the consumers of Group 1 prefer the ribbing designs over the non-ribbing design on plastic bottles. Between the two ribbing designs, the consumers preferred the vertical ribs (56%) over the horizontal ribs (42%).

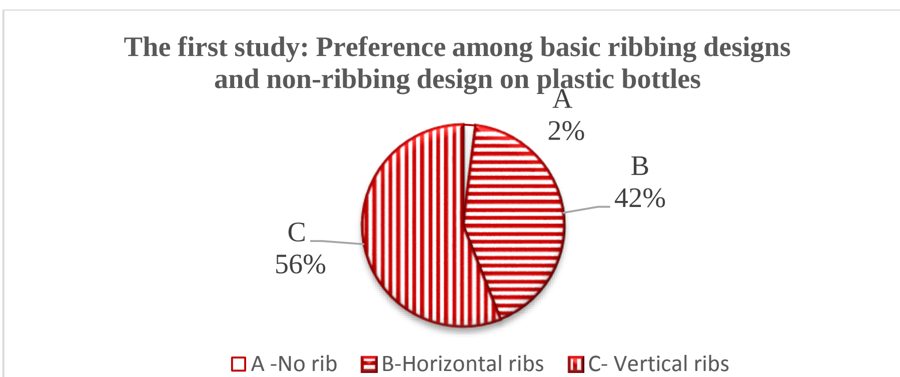

Figure 48: The first study- Preference among basic ribbing designs and non-ribbing design on plastic bottles

Besides, this study also aims to identify the shape of rib which is favoured by the consumers of Group 1. Three shapes of ribs on plastic bottles were introduced to the consumers, including (1) D - straight line ribs, (2) E - embossed rectangular shape ribs, and (3) F - wavy ribs. These ribs' shapes are highlighted by red lines on the bottles' bodies as depicted in Figure 49. A blank sample was used just for reference of a non-ribbing bottle. The consumers selected the design they liked most among the three shapes of ribs, excluding a blank sample, based on visualization and handling.

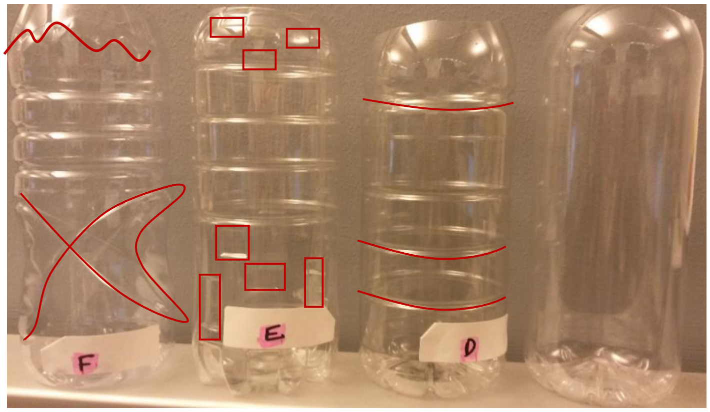

Figure 49: The variety shapes of ribs on plastic bottles

Among these three shapes of ribs, 64% of the consumers selected the design F, 20% of the consumers selected the design E, while only 16% of the consumers selected the design D. The result is illustrated on a diagram in Figure 50. Thus, it can be concluded that the wavy rib is the most favourite design on plastic bottles for the consumers of Group 1.

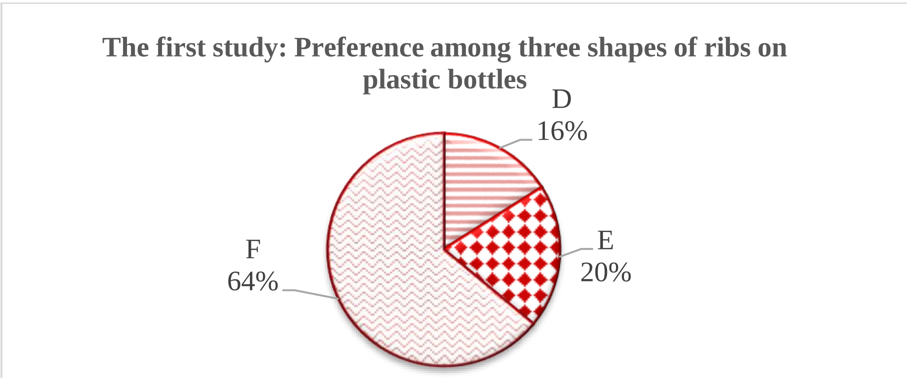

Figure 50: The first study - Preference among three shapes of ribs on plastic bottles

In order to explore deeper if rib designs support for any convenience functions, a question and observation were carried out on three plastic bottles of 1.5 litres. The consumers were introduced to three plastic bottles: (1) A- a non-ribbing bottle, (2) B- a deep rib bottle, and (3) C- a bottle with many shallow ribs, as seen in Figure 51. In the figure, two red lines on the bottle B highlight the deep ribs.

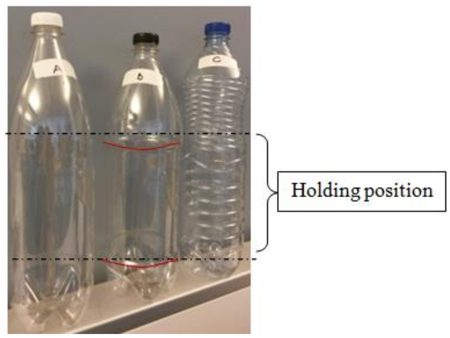

Figure 51: Three research bottles of 1.5 litres

The consumers were asked to hold these bottles by one hand at the holding position and pour water out. After pouring, the consumers were asked which bottle made them feel easiest to handle. The result is visualized in Figure 52. 80% of the consumers selected the design B as the deep ribs created a locking function. Thanks to that, the bottle was not glided out of their hands. 18% of the consumers felt the design C was the most convenient one. Only 2% of the consumers selected the design A. The result shows that for the consumers of Group 1, ribs help them to handle easily a large bottle and also that a deep rib bottle is more convenient than a bottle with many shallow ribs.

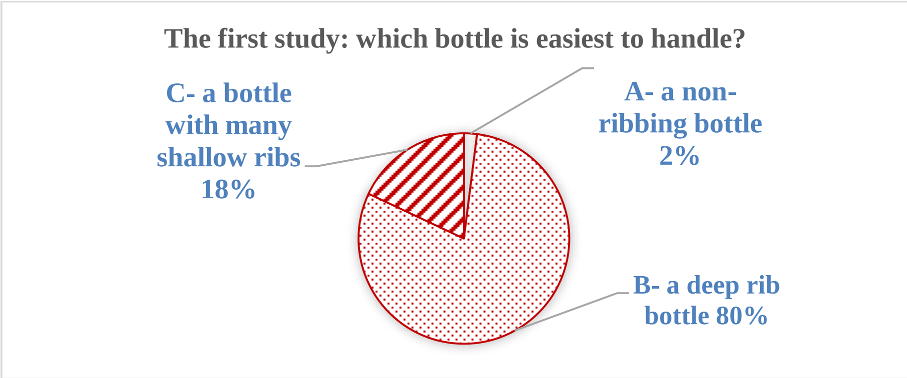

Figure 52: The first study- Which bottle is easiest to handle?

In summary, in the perception of the consumers of Group 1, rib designs make plastic bottles more appealing and more convenient during handling and use. In terms of aesthetic appearance, the consumers prefer the ribs with a wavy shape and vertical direction. With large bottles, the consumers prefer deep ribs over shallow ribs regarding the convenience.

4.1.3 Driven criteria for consumers' purchasing decision

After the consumers selected a design they preferred for a plastic bottle, they were asked if they were willing to pay 1 Swedish krona (kr) more to purchase the preferred bottle if it contained the same product and volume as other bottles. In the case the bottles were only different in aesthetic appearance, 54% of the consumers agreed to pay 1kr more while 46% of the consumers chose the cheaper bottle, as seen in Figure 53. It shows that the aesthetic appearance of packaging is not a strong element to convince the consumers of Group 1 to pay more.

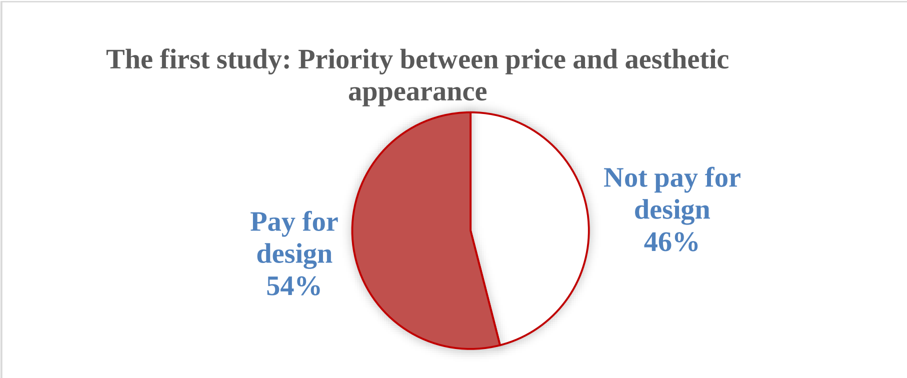

Figure 53: The first study- Priority between price and aesthetic appearance

When investigating the priority between price and convenience, as shown in Figure 54, 58% of the consumers were willing to pay 1kr more while 42% of the consumers bought the cheaper bottle. Therefore, it can be understood that comparing to the aesthetic appearance, the convenience function of packaging is more persuasive for the consumers of Group 1 to pay more.

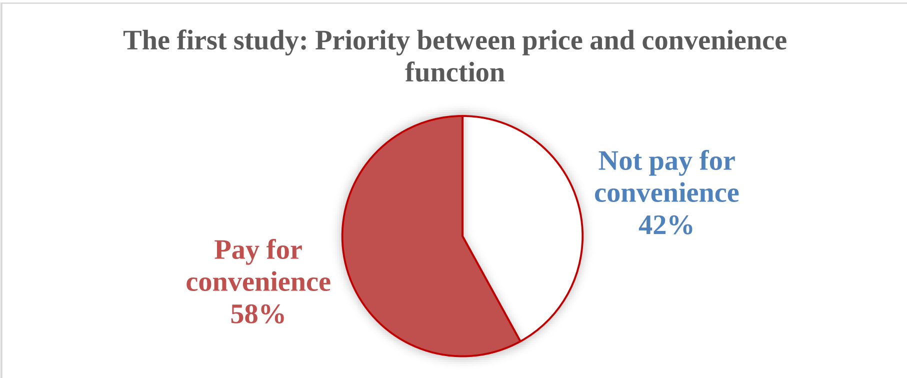

Figure 54: The first study- Priority between price and convenience function

However, when the consumers were asked if they were ready to pay 1kr more for an environmental friendly packaging, 82% of the consumers agreed to pay more while 18% of the consumers were not willing to do so. The result is shown in Figure 55.

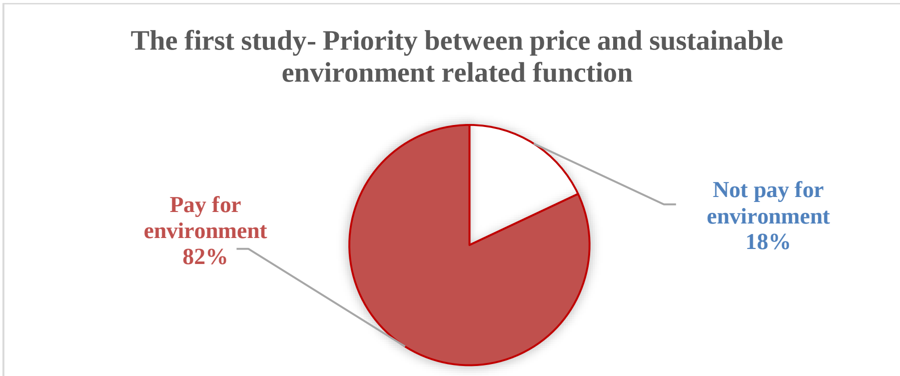

Figure 55: The first study- Priority between price and sustainable environment related function

The three comparisons present that the priority of three criteria which affect purchasing decision of the consumers of Group 1. The most persuasive criterion that the consumers are ready to pay more for is the environmental friendliness. The convenience function and the aesthetic appearance are important issues to appeal consumers but it is not quite clear that the consumers are willing to pay more for them.

4.1.4 Consumer perception toward ribs on carton containers

To identify favourite rib designs on carton containers in the consumers' perception, six rib designs (design A, design B, design C, design D, design E, and design F) were introduced to the consumers of Group 1. The consumers were asked to select two rib designs they liked and prioritized their choices. The result shows that the three most preferred rib designs are design D (26%), design C (23%), and design F (17%), as seen in Figure 56.

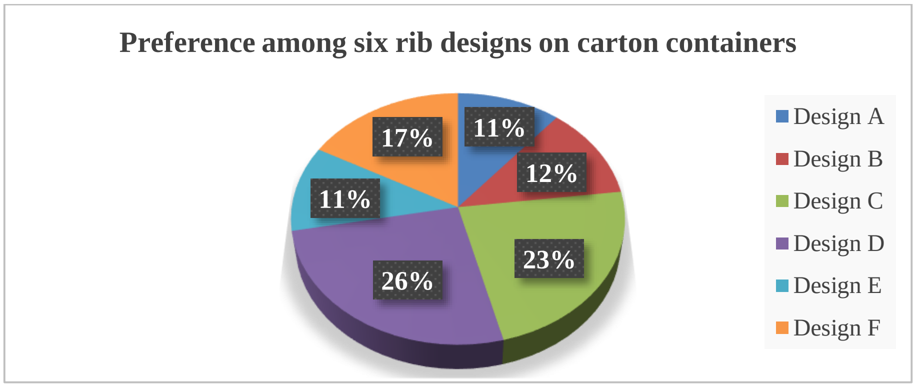

Figure 56: Preference among six rib designs on carton containers

4.2 Results of the second consumer study

The second consumer study was conducted on the consumers of Group 2 with the same purposes as the first one. The method and questionnaire of the second study are as similar as the ones of the first study. However, in the questionnaire, the question that is related to the favourite rib designs on carton containers was removed.

4.2.1 Consumer perception toward ribs on metal cans

According to the analysis of the result as seen in Figure 57, 48% of the consumers preferred the ribbing can while 52% of the consumers preferred the non-ribbing can. Therefore, it cannot be concluded that the consumers of Group 2 prefer the ribs on metal cans, in terms of convenience during holding.

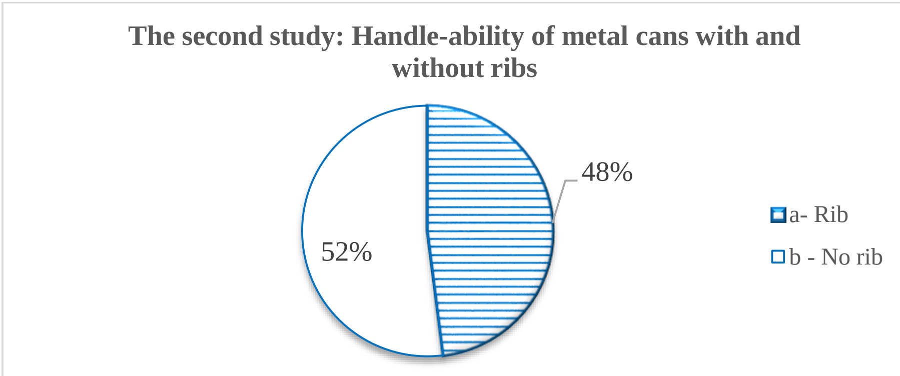

Figure 57: The second study-Handle-ability of metal cans with and without ribs

Regarding the effect of ribs on the readability product information on cans, 96% of the consumers answered that reading information on the non-ribbing can is much easier than doing so on the ribbing can. Only 4% of the consumers said that the ribbing design makes information on the can body easier to be read. The result as seen in Figure 58 shows one disadvantage of ribs for the convenience of consumers – the readability product information.

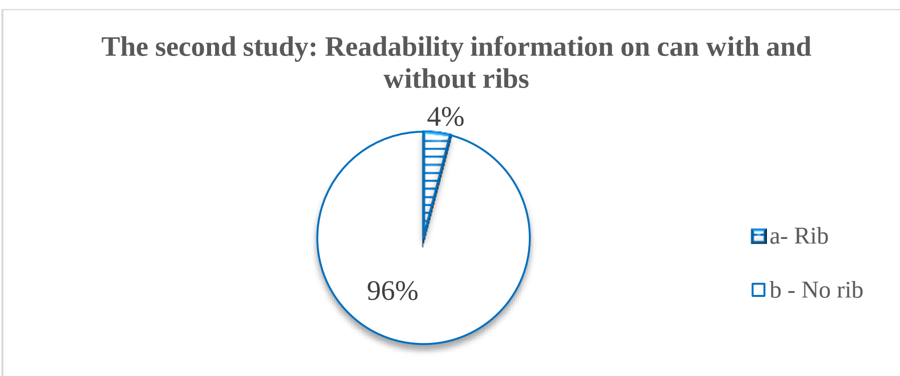

Figure 58: The second study- Readability information of can with and without ribs

In general, ribs on metal cans do not provide any convenience but cause a disadvantage which is hindering the readability product information, according to the perception of the consumers in the Group 2.

4.2.2 Consumer perception toward ribs on plastic bottles

When comparing the two ribbing designs to the non-ribbing design, the consumers of Group 2 prefer the ribbing designs over the non-ribbing one. In detail, 90% of the consumers selected the ribbing designs (B and C) while 10% of the consumers selected the non-ribbing design (A). In addition, the consumers preferred the vertical ribs (58%) over the horizontal ribs (32%), as seen in Figure 59. Therefore, it can be concluded that the consumers of Group 2 prefer the ribbing designs, especially the vertical ribs, over the non-ribbing design on a plastic bottle.

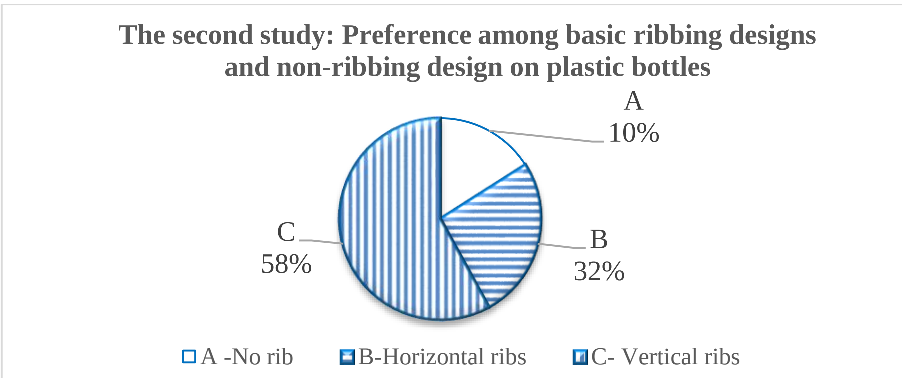

Figure 59: The second study- Preference among basic ribbing designs and non-ribbing design on plastic bottles

Regarding the shape of ribs on plastic bottles, the consumers of Group 2 prefer the wavy ribs. In particular, 70% of the consumers selected the design F- wavy ribs, 16% of the consumers selected the design D- straight line ribs, and 14% of the consumers selected the design E- embossed rectangular shape ribs. The result is visualized in Figure 60.

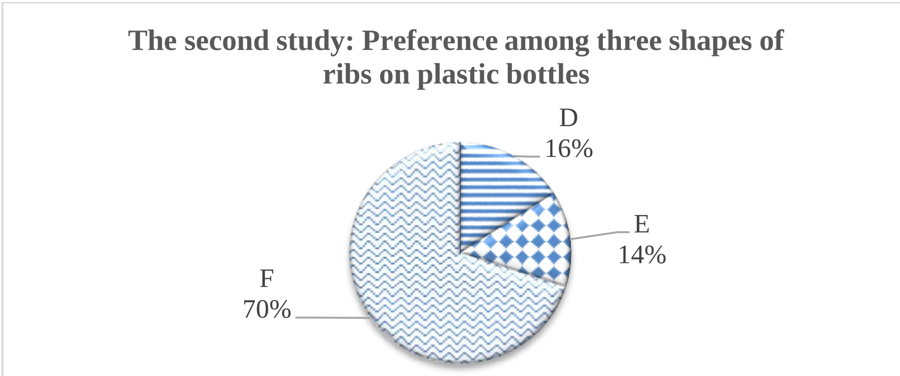

Figure 60: The second study- Preference among three shapes of ribs on plastic bottles

Meanwhile, in terms of convenience, the result visualized in Figure 61 shows that a deep rib bottle is the most convenient one for the consumers of Group 2 to handle by one hand. Particularly, 64% of the consumers who selected the design B explained that they felt this design more rigid and stable than the others while 30% of the consumers said that the design C was the easiest one to handle. Only 6% of the consumers selected the design A. Therefore, it is certain that the ribbing designs, especially the deep ribs on plastic bottles provide convenience function in the perception of the consumers in the Group 2.

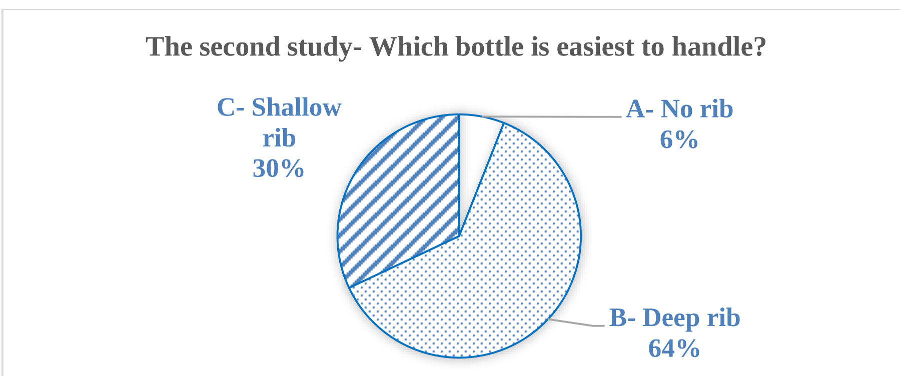

Figure 61: The second study- Which bottle is easiest to handle?

In summary, in the perception of the consumers in the Group 2, rib designs provide both aesthetic appearance and convenience function for plastic bottles. In terms of aesthetic appearance, the consumers prefer the ribs with vertical direction and/or a wavy shape.

Regarding convenience function, a deep rib is considered as the most convenient design for the consumers.

4.2.3 Driven criteria for consumers' purchasing decision

When two bottles are only different in aesthetic appearance, the consumers were asked if they were willing to pay 1 kr more to purchase the more appealing bottle. The result shows that 38% of the consumers agreed to pay 1kr more while 62% of consumers chose the cheaper bottle, as seen in Figure 62. Based on that, it can be found that the aesthetic appearance of packaging is not a driven criterion for the consumers' purchasing decision.

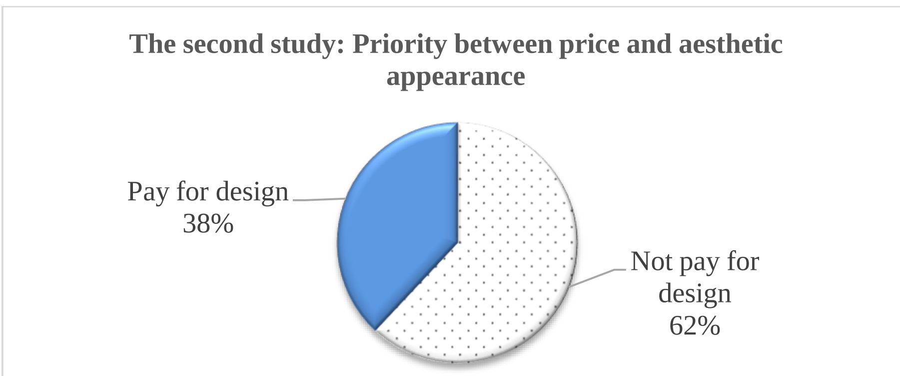

Figure 62: The second study- Priority between price and aesthetic appearance

However, the convenience function is prioritized in the purchasing decision of the consumers. As seen in Figure 63, 56% of the consumers were willing to pay 1kr more for a bottle that was easier to handle, while 44% of the consumers were not.

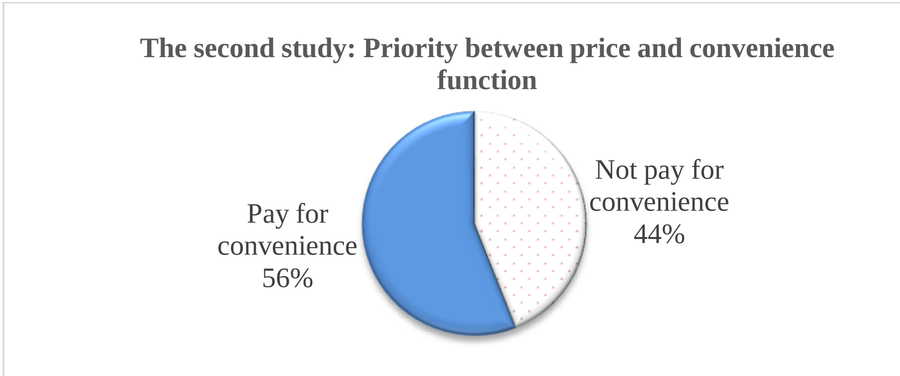

Figure 63: The second study- Priority between price and convenience function

Comparing to the convenience, the environmental friendliness is much stronger criterion to convince the consumers of Group 2 to pay more. In detail, 82% of the consumers agreed to pay 1kr more for the environmental friendly packaging while only 18% of the consumers were not willing to do so. The result can be seen in Figure 64.

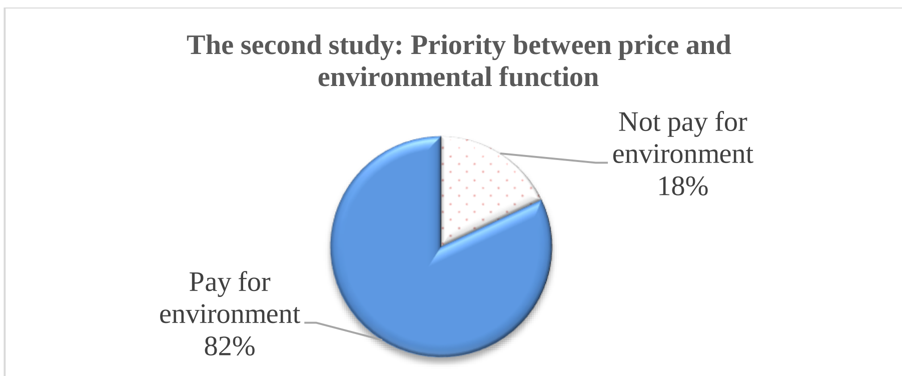

Figure 64: The second study- Priority between price and environmental function

The three comparisons present the priority of three criteria which affect purchasing decision of the consumers of Group 2. The most convinced criterion that the consumers are ready to pay more for is the environmental friendliness. The convenience function is an important criterion but it is not clear that the consumers of Group 2 are willing to pay more for it, similarly to the findings on Group 1. However, the consumers of Group 2 will not pay more for the aesthetic appearance of packaging.

4.3 Comparison between the two studies and discussion

The comparison between the two studies is carried out to create fundamentals for discussion on the perception of the researched Swedish consumers toward ribs on plastic bottles, metal cans, and carton containers. The results from the comparison also help to figure out the importance of the three selected criteria – aesthetic appearance, convenience, and environment which might affect the consumers' purchasing decision.

4.3.1 Comparison on the attributes of the two researched groups

As mentioned in Chapter 2, in order to compare the two groups, the consumer studies were designed to ensure: (1) the ratio between male and female consumers of each group is 1:1, (2) the consumers in each group work in different areas with the similar ratios between the two groups, and (3) the age ranges of the consumers between the two groups are similar. However, in reality the age ranges of consumers and the ratios of different working areas between the two groups are different due to the volunteer participation of consumers. The detailed differences are pointed out by the two following analyses.

The first difference is in the age ranges of the consumers between the two groups. As seen in Figure 65, the consumers of Group 1 are mainly from 31 to 65 years old (82%) while the consumers of Group 2 are mainly from 20 to 40 years old or from 51 to 65 years old (82%). In the Group 2, the young people (20-40 years old) contribute a larger part (68%) than the old people (51-65 years old) (14%). This can be explained by the fact that the consumers of Group 1 are employees while the consumers of Group 2 are mainly students (48%) or retirees whom the author can reach in retail stores. Moreover, Lund is a university city, thus the number of young students makes up the largest proportion in the city population (Megan Grindlay, 2015). Even though there is a difference in the age ranges between the two groups, the largest age range of both groups is 31-40 years old. Thus, the total choices of each group may be affected mainly by the choices of this age range. Consequently, the results of these consumer studies are applicable for the target Swedish consumers who are 31-40 years old. The results of the consumer study on Group 2 may be applicable for the younger Swedish consumers who are 20-40 years old. However, the results of these consumer studies may not be applicable for the consumers who are younger than 20 or older than 65 years old.

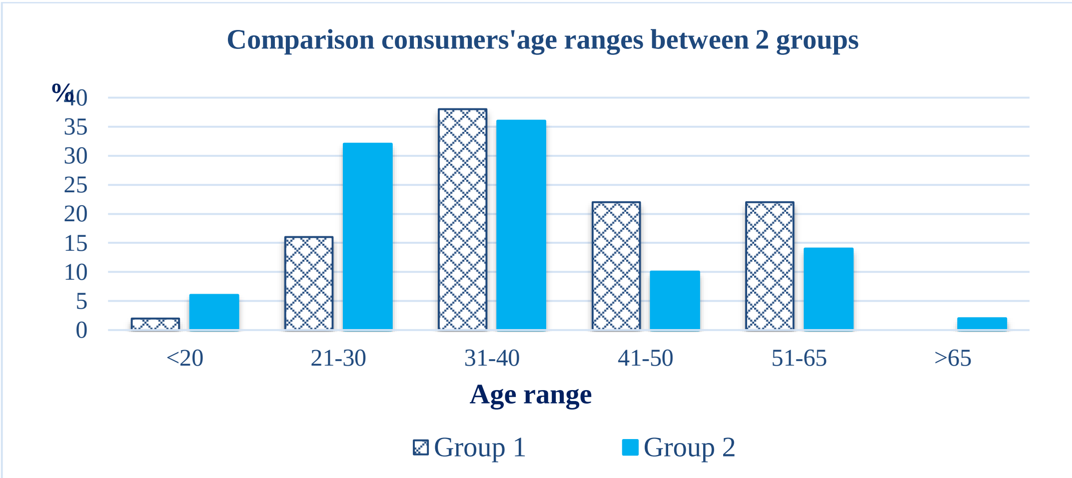

Figure 65: Comparison consumers 'age between two groups

The difference in the age ranges may leads to the difference in income which affects purchasing decision. In detail, the consumers of Group 1 are mainly 31-65 years old and have permanent jobs. On the contrary, the consumers of Group 2 are mainly students who are 20-40 years old. As a result, the consumers of Group 1 may have higher income than the consumers of Group 2 and the purchasing decision of Group 1 may be different from the one of Group 2 because of the impact of income.

The second difference is in the ratios of working areas between the two groups. It is easy to see in Figure 66 that the variety of working areas in Group 2 is wider than the one in Group 1. In particular, the working areas of the consumers in Group 1 are mainly Research and Development (R&D), Customer service, and Purchasing, while the working areas of the consumers in Group 2 vary in many different areas, such as Administration, Production, Sale & Marketing (MKT), Human resource, Economics, Finance, HSE (Health, Safety, and Environment). One should be noted that the working area in Group 2 is also the studying area. As mentioned above, the proportion of consumers who are students in Group 2 is 48% - the largest one in this group. Consequently, even though the consumers of Group 2 have different perspectives based on their various working or studying areas, the purchasing decision of Group 2 in general might be affected mainly by the income of the consumers who are students. It might be a difference comparing to Group 1 with the purchasing decision influenced by 100% of the consumers who are employees.

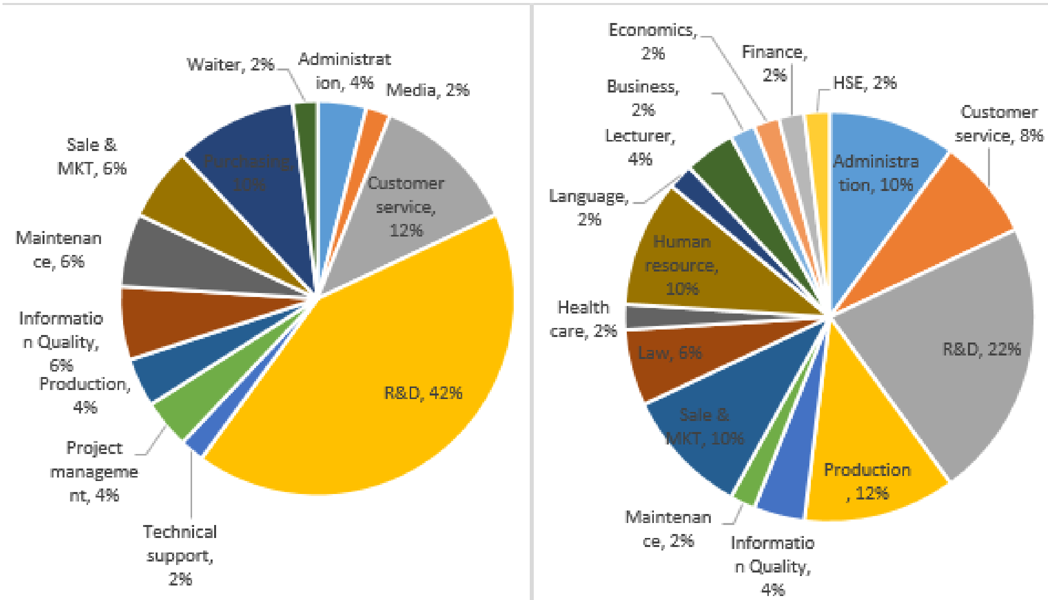

Figure 66: The ratios of working areas in two groups (Left - Group 1, Right - Group 2)

These differences can lead to the difference in the perception of the two groups. Therefore, a statistical Chi-square test is used to check the correlation of two groups and their perception before comparing two groups based on the proportion of consumers' choices by percentage. It should be noted that the formula (I) is used to calculate the chi-square value χ^2 instead of using the excel formula (II) to find out the ρ value as mentioned in Chapter 2. Consequently, the critical value from the table in APPENDIX C is used to compare with calculated chi-square values.

4.3.2 General consumer perception toward ribs on food packaging

❖ **Metal cans**

Regarding the metal cans, the chi-square tests are used to check if there is any correlation between the two groups in their perception toward the handle-ability and readability of ribs. In terms of handle-ability, the null hypothesis is "there is no significant difference in the perception toward the handle-ability of ribs on metal cans between the two groups". The statistic is calculated as shown in Table D1 of Appendix D. According to the calculation, the chi-square value (0.16) is lower than the critical value (3.84), thus the null hypothesis is not rejected. It means that both groups have the same perception toward the handle-ability of ribs on cans. Meanwhile, according to the proportion of answers in both groups by percentage as seen in Figure 67, it cannot be concluded that the ribs provide any convenience (handle-ability) for cans in the consumer perception. In addition, another chi-square test is used to check if there is any difference in the perception toward the handle-ability of ribs on metal cans between female and male consumers. The result in Table D2 of Appendix D shows that the consumer perception toward the handle-ability of ribs on cans is independent with the gender. Indeed, the observation showed that the consumers did not recognize the difference between the two designs until the ribs were mentioned. Although the consumers must choose one design between the two ones, they also said that the difference between them was not really significant. The result can be explained by the fact that metal cans are firm, thus the little added rigidity from ribs' structure is hard to be recognized by consumers. Moreover, the metal cans used in these studies are 274ml cans. These cans are small enough to be hold easily by one hand for both male and female consumers. Thus the consumers did not see the significant difference between the ribbing can and the non-ribbing can.

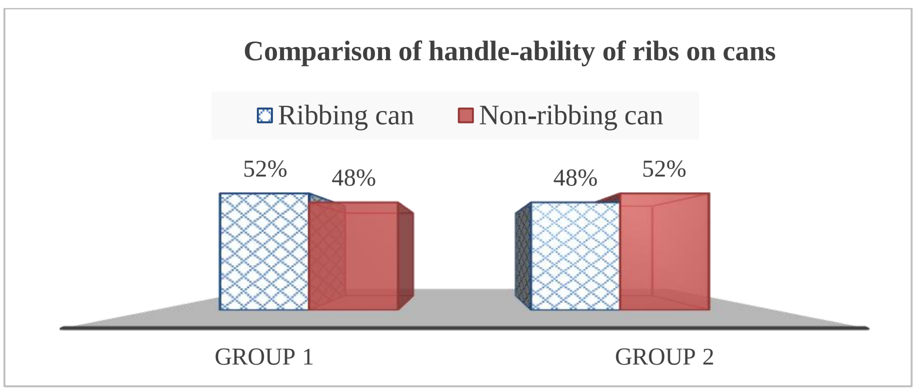

Figure 67: Comparison of handle-ability of ribs on cans

In terms of readability, the null hypothesis is "there is no significant difference in the perception toward the readability product information on the ribbing can between the two groups". The calculated results in Table D3 of Appendix D indicate that the two groups have the same perception toward the readability information on the ribbing can. As seen in Figure 68, both groups agree that the ribbing can is clearly harder to read product information than the non-ribbing can. It can be explained by the fact that the ribs create an uneven surface on the can, similarly to the ribbing plastic bottles' disadvantage found in the theoretical framework (Amcor, 2005). The disadvantage of ribs also provides another explanation to why the ribs on metal cans are normally hidden under paper labels besides the reason of production cost which was mentioned in Chapter 3 (Bradley, 2005).

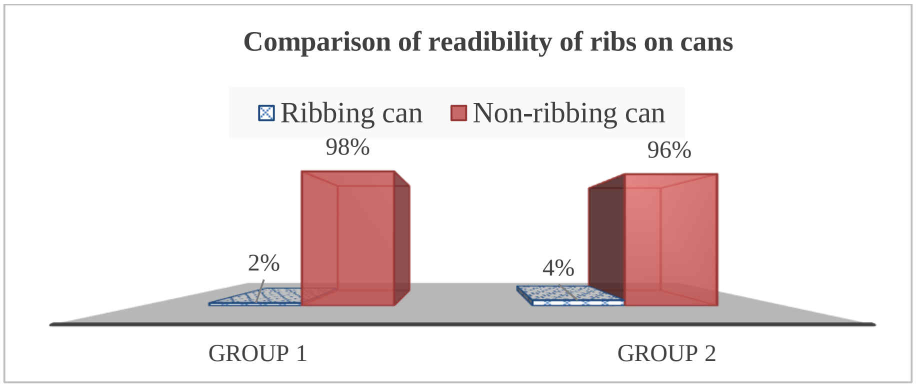

Figure 68: Comparison of readability of ribs on cans

❖ **Plastic bottles**

Relating to plastic bottles, three statistical tests are conducted to check the correlation between the two groups in their perception toward the favourite designs and the convenience function of ribs. The first statistic is calculated as shown in Table D4 of Appendix D. The null hypothesis is "there is no significant difference in the favourite design of ribs' direction on plastic bottles between the two groups". According to the results, the two groups have the same favourite design of ribs' direction on plastic bottles.

Similarly, the second statistic is calculated as shown in Table D5 of Appendix D to check the correlation between the two groups in their favourite design of ribs' shape on plastic bottle. The chi-square test points out that although the two groups are different in their attributes, they still have the same favourite design of ribs' shape on plastic bottles.

Figure 69 displays the two graphs that are used to visualize the preference of the consumers in the two groups toward the ribs' direction and ribs' shape on plastic bottles. The results show that the vertical direction and the wavy shape are the most preferred designs of ribs on plastic bottles by the consumers of both groups. In detail of both groups, the vertical rib design (57%) is preferred over the horizontal rib one (37%) and the wavy ribs design (67%) is preferred over the rectangular rib one (17%) or the straight line rib one (16%). Besides, the ratio between male and female consumers who chose the vertical ribs and the wavy ribs is 1:1. Therefore, it could be said that the consumer preference toward rib design is independent with the gender. This implies that packaging companies can produce one design to attract both the genders.

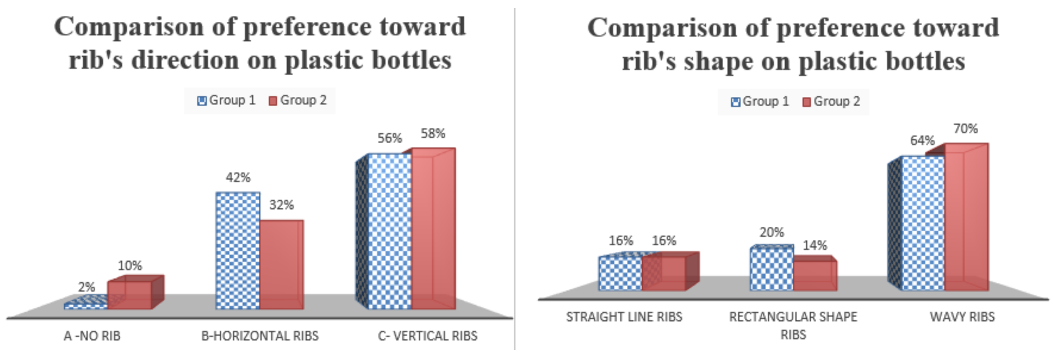

Figure 69: Comparison of preference toward rib's design on plastic bottles

Indeed, the observation showed that some of the consumers who chose the wavy ribs preferred the embossed rectangular shape ribs when visualizing in the beginning. However, when these consumers handled the two bottles, they felt the wavy ribs made the bottle tighter fit their hands. Thus they changed their preference to the wavy ribs. This observation reveals that the consumers seem to prefer the convenience function over the aesthetic appearance when choosing a packaging. In reality, some consumers are not detail-oriented people or in a hurry. In this case, they may select packages based on the aesthetic appearance rather than take time to "test" packages before buying them. Another scenario is when people buy a product for the first time. In this case, the aesthetic appearance of packaging makes a large impact on consumers' purchasing decision. In contrast, if consumers are detailed-oriented or have more time to consider, they may choose packages based on convenience functions, as what is found in this research. Especially when consumers have already had bad experience of the inconvenience packaging, they may not choose it anymore, even if it is appealing, according to D'Souza et al. (2006). Therefore, in order to attract consumers and create the loyalty to the product brand, packaging companies need to include both attributes - aesthetic appearance and convenience in their design. In particular, if packaging companies focus on on-the-go products, these attributes are much more important.

Lastly, the third statistic is implemented to check the null hypothesis "there is no significant difference in the perception toward the convenience function of ribs on plastic bottles between the two groups". As the calculation in Table D6 of Appendix D, the perception of the two groups toward the convenience function of ribs on plastic bottles is similar whatever the difference in the groups' attributes.

According the proportion of responses seen in Figure 70, the consumers of both groups agree that the ribs, especially the deep ribs support grabbing heavy bottles easier. According to observation, the female consumers in both groups felt difficult when handling the bottle without ribs because they had quite small hands. When grabbing the deep rib bottle, most of female consumers commented that the deep ribs helped to lock their hands and prevent the bottle from falling down. In contrast, the male consumers can handle quite well all three bottles. As a result, the female consumers gave quickly their preference toward the ribbing bottles while the male consumers needed to consider carefully. During the consideration, the appearance of bottles may affect the male consumers' choice. Indeed, the quantitative data shows that the female consumers select mainly the design B (76%) while the male consumers also select the design B with lesser proportion (68%). Therefore, the deep rib design is applicable for large containers and helps packaging companies reach the target consumers who are women and children.

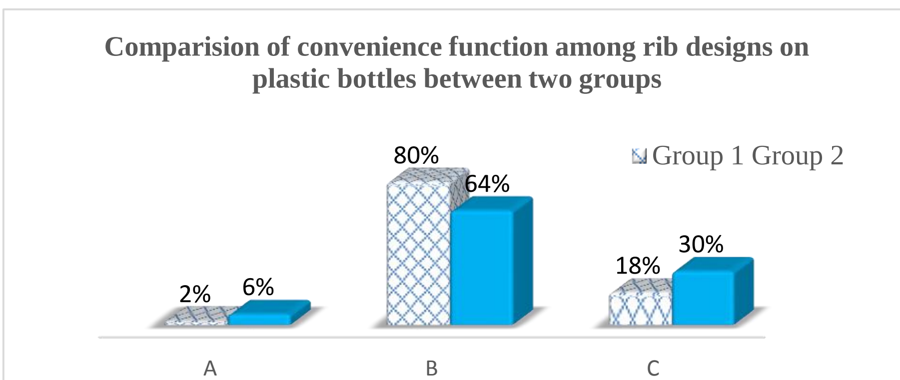

Figure 70: Comparison of convenience function among rib designs on plastic bottles between 2 groups

4.3.3 Driven criteria for consumers' purchasing decision

In order to investigate driven criteria for the purchasing decision of consumers, the statistical test is used to evaluate the correlation between the two groups toward these criteria. There are 3 statistical tests in relation to three criteria of packaging: (1) aesthetic appearance, (2) convenience, and (3) environmental friendliness.

The first statistic is calculated with the null hypothesis “there is no significant difference between the two groups toward the impact of packaging’s aesthetic appearance to their purchasing decision”. According to the results shown in Table D7 of Appendix D, one can be concluded is that the consumers of both groups have the same purchasing decision toward the aesthetic appearance of packaging. Thus, the two groups can be gathered into one big group to evaluate the impact of packaging’s aesthetic appearance to general consumers’ purchasing decision. It should be noted that for Group 1, it is not clear if the consumers are willing to pay more for the aesthetic appearance of packaging. However for Group 2, the consumers do not completely pay more for this criterion. Thus, to have the general conclusion about the impact of this criterion to purchasing decision, it should gather two groups into one group of researched Swedish consumers. The summary of two groups’ responses is shown in Table 3 and the result is visualized on Figure 71. In addition, the chi-square result as shown in Table D8 of Appendix D presents that there is no significant difference between female and male consumers toward the impact of packaging’s aesthetic appearance to their purchasing decision.

Table 3: Purchasing decision toward packaging’s aesthetic appearance of Swedish consumers

Aesthetic appearance	Group 1	Group 2	Swedish consumers
Not pay	23	31	54
Pay	27	19	46
Total	50	50	100

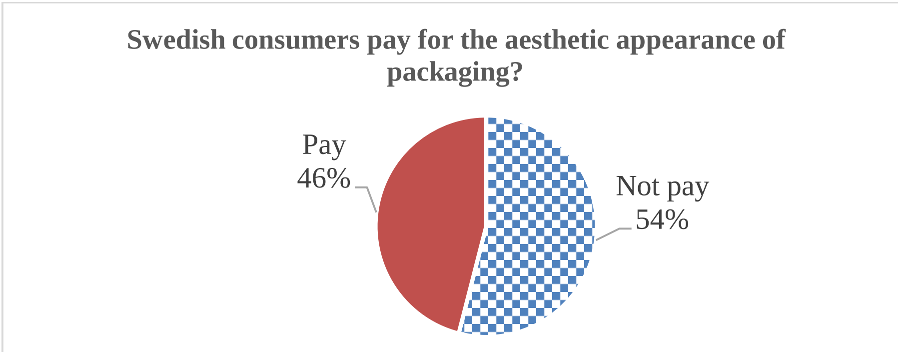

Figure 71: Swedish consumers pay more for aesthetic appearance of packaging?

Based on the result, it can be concluded that more than half of the researched Swedish consumers are not willing to pay more for the aesthetic appearance. This result is similar to the consumer research of Coca Cola on a new contour packaging in 1998 (Beach packaging design, 1998). However, if profit from the group of Swedish consumers who are willing to pay more for aesthetic appearance is big enough to satisfy companies' expectation, packaging companies are still able to develop an appealing packaging to target this group.

The next statistic is carried out to check the correlation between the two groups toward the impact of packaging's convenience function to their purchasing decision. Based on Table D9 of Appendix D, the consumers of both groups have the similar purchasing decision toward the convenience function of packaging. It also means that the two groups can be grouped into one group of the researched Swedish consumers to evaluate the impact of packaging's convenience function to their purchasing decision. The total responses of the researched Swedish consumers is summarized in Table 4 and visualized on Figure 72.

Table 4: Purchasing decision toward packaging's convenience function of Swedish consumers

For convenience function	Group 1	Group 2	Swedish consumers
Not pay	21	22	43
Pay	29	28	57
Total	50	50	100

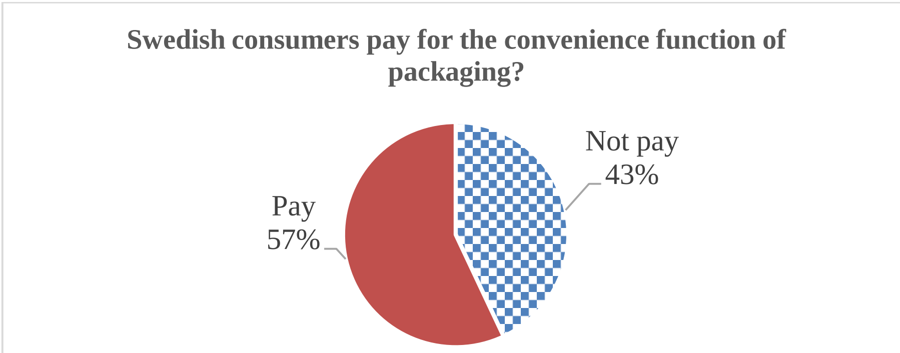

Figure 72: Swedish consumers pay more for convenience function of packaging?

Based on the result on Figure 72, 57% of the researched Swedish consumers are willing to pay more for the packaging's convenience function. This proportion is quite similar to the proportion of the consumers who are willing to pay more for the convenience function in each group. In addition, the chi-square result shown in Table D10 of Appendix D presents that there is no significant difference between female and male consumers toward the impact of packaging's convenience function to their purchasing decision. Besides, the detail age ranges of the group who are ready to pay more for the convenience function are also checked. The result shows that, the two largest subgroups in the group who pay more for the convenience function are the 31-40 years old group (37%) and the 51-65 years old group (25%). It can be explained by the fact that normally 31-40 years old people have children and handle large bottles (family size packages) often. Thus they want to buy convenient packaging for their children to handle for reducing risk of spilling product. Besides, they may have permanent income to pay more for this function. For 51-65 years old people, their children may be mature enough to hold big containers. However, the 51-65 years old people may not have strong hands to hold large containers and they might have a good financial situation, thus they are ready to pay a little bit more (1kr) for the convenience function. Based on this result, packaging companies targeting the 31-40 years old consumers or the 51-65 years old consumers should focus on the convenience function in their packaging design. Thanks to that, they can increase product's price but still attract more consumers in these age ranges.

Finally, the third statistic is calculated to check the correlation between the two groups in their purchasing decision toward the environmental friendliness of packaging. Based on Table D11 of Appendix D, the two groups completely have same purchasing decision toward the environmental friendliness of packaging. The proportion of the responses by percentage as seen in Figure 73 shows that the consumers of both groups (82%) are ready to pay more for this criterion.

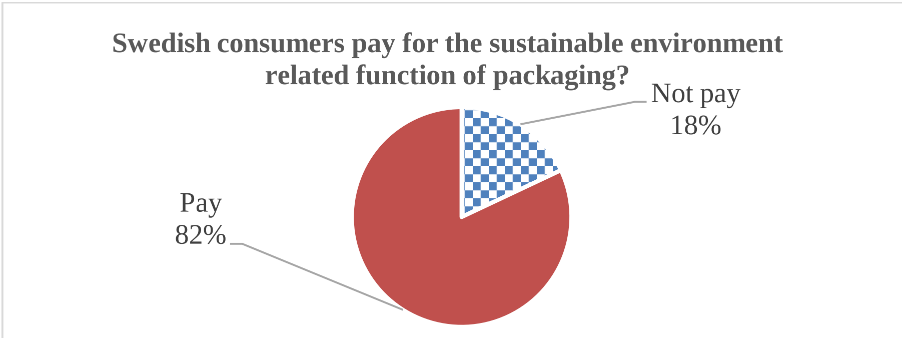

Figure 73: Swedish consumers pay more for the environmental friendly packaging?

This result is matched with findings in the consumer research reported by Nielsen for general goods and services (2014). According to the global consumer research of Nielsen (2014) on 30,000 consumers in 60 countries, more than half of global respondents (55%) said that they were willing to pay more for the environmental function. However, the proportion of the consumers who pay more for the environmental function in this study (82%) is higher than the proportion found by Nielsen (2014) which was 55%. It can be explained by the level of education of the researched consumers in these studies. As mentioned before, the researched Swedish consumers are mainly employees in the packaging industry and young students who are living in Lund –one of big cities in Sweden. As a result, they may have higher level of education and recognition toward environmental issues than general consumers. Therefore, they are willing to pay more for the environmental function. Besides, there is still a possibility that some consumers pretend to pay more but do not do so in reality.

The final point is comparing to the convenience function, the environmental friendliness seems more convinced for the researched Swedish consumers to pay more (82% of the consumers are willing to pay more for the environmental friendliness while 57% of the consumers are ready to pay more the convenience function). This result might be contradicted with the findings of D'Souza et al. (2006) from a consumer research on Australian consumers. D'Souza et al. (2006) indicated in their study that the past experience of the products' convenience, not the environmental function was the most important criterion affecting consumers' purchasing decision. The contradiction might be explained by the different sampling (Australian and Swedish consumers). Besides, it may come from the higher level of education of the researched Swedish consumers in these studies compared to the general Australian consumers participated in the study of D'Souza et al. (2006). However, there could also be other explanations for this results: (1) the researched Swedish consumers might exaggerate their willingness to pay more for the environmental friendliness or (2) the Swedish consumers might answer differently when being asked directly: "would you pay extra for a more environmentally friendly package that was not very convenient if you can get a very convenient package for the same price?"

In general, it can be concluded that among the three selected criteria, the environmental function and the convenience of packaging are the important criteria for the consumers' purchasing decision. This result is particularly applicable for packaging companies who target urban consumers who have high level of education.

4.4 Suggestion of rib designs for plastic bottles and for carton containers

The correlation statistics and comparisons between the two groups show that both groups have similar (1) preference toward the rib designs on plastic bottles, (2) perception toward ribs on plastic bottles and metal cans, and (3) driven criteria for their purchasing decision. Thanks to that, some suggestions of rib designs for packaging can be figured out and presented as following.

Regarding plastic bottles, ribs should be wavy and in vertical direction as illustrated in Figure 74. In order to provide convenience function, deep ribs should be developed, especially on large bottles.

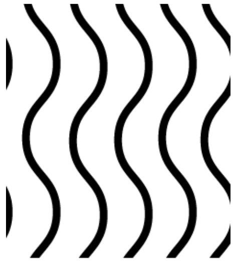

Figure 74: Wavy ribs in vertical direction

Regarding carton containers, three rib designs are suggested to develop because these rib designs are preferred by the researched Swedish consumers in Group 1. Since both groups have similar perception and preference of rib designs on plastic bottles and metal cans, there is a high possibility that the consumers of Group 2 prefer the same rib designs as the consumers of Group 1.

5 CONCLUSION & FUTURE WORK

This chapter summarizes the findings from the literature research and the consumer research in order to answer the research questions posted in Chapter 1.

5.1 Mapping the functions of ribs on food packaging

The findings from the literature research and the consumer research show that rib designs present many functions in different aspects, including technical, economic, environmental, marketing, and consumer convenience. Depending on design and kind of food packaging, ribs provide some specific functions. The map illustrated in Figure 75 summarizes ribs' functions on plastic bottles, metal cans, and food packaging in general.

Indeed, the technical, economic, and environmental functions in the map used to answer the first research question: (Q1) "What are the technical functions of rib designs on food packaging as well as the impact of rib designs on economic and environmental aspects?"

Regarding technical functions, rib designs help to (1) prevent deformation caused by the sterilisation process or external pressures, (2) increase top load strength, (3) enhance resistance to bending, and (4) reduce packaging materials and packaging weight. In the case of metal cans, rib designs can protect coating layers of metal sheets used to make cans from cracks, corrosion, and leakage or support the sterilisation process. Thanks to these functions, original appearance of product packaging is maintained during the supply chain. Besides, in the case of carton materials, rib designs create a thermal insulation function or optimize the stability of product.

Thanks to the technical functions, rib designs give packaging companies opportunities to minimize costs from using less packaging materials, increasing production capacity and transportation efficiency, and from less damaged products. Moreover, appealing rib designs help to increase sales. In addition, the technical functions of rib designs decrease negative environmental impacts by reducing natural resource usage, energy consumption, and emissions caused by the production and the recycling processes of packaging.

However, rib designs might have some disadvantages such as hindering the labelling process, causing non-standard stacking, high initial investment for changing production lines or making complex moulds.

In addition, the marketing and convenience functions in the map are used to answer the second research question: (Q2) “What is the Swedish consumers’ perception toward the rib design on food packaging?”

In terms of marketing, the researched Swedish consumers agreed that rib designs provide better aesthetic appearance for packaging. Thanks to that, rib designs support attracting consumers, especially in the case of new products or on-the-go products. Consequently, rib designs help to differentiate product brands, enhance consumption, as well as prevent counterfeiting. Regarding convenience functions, the researched Swedish consumers said that the rib designs make packaging more tightly fit on their hands and more rigid when grabbing, especially for large packages. Thanks to that, the rib designs help to prevent consumers from slipping large packages or spilling of products, especially carbonated beverages. Some rib designs also provide the squeezing attribute which helps consumers easily to fold or squeeze emptied packages after use and save more space in their waste baskets at home. However, rib designs can obstruct readability of product information on packaging when product information is printed directly on the ribs.

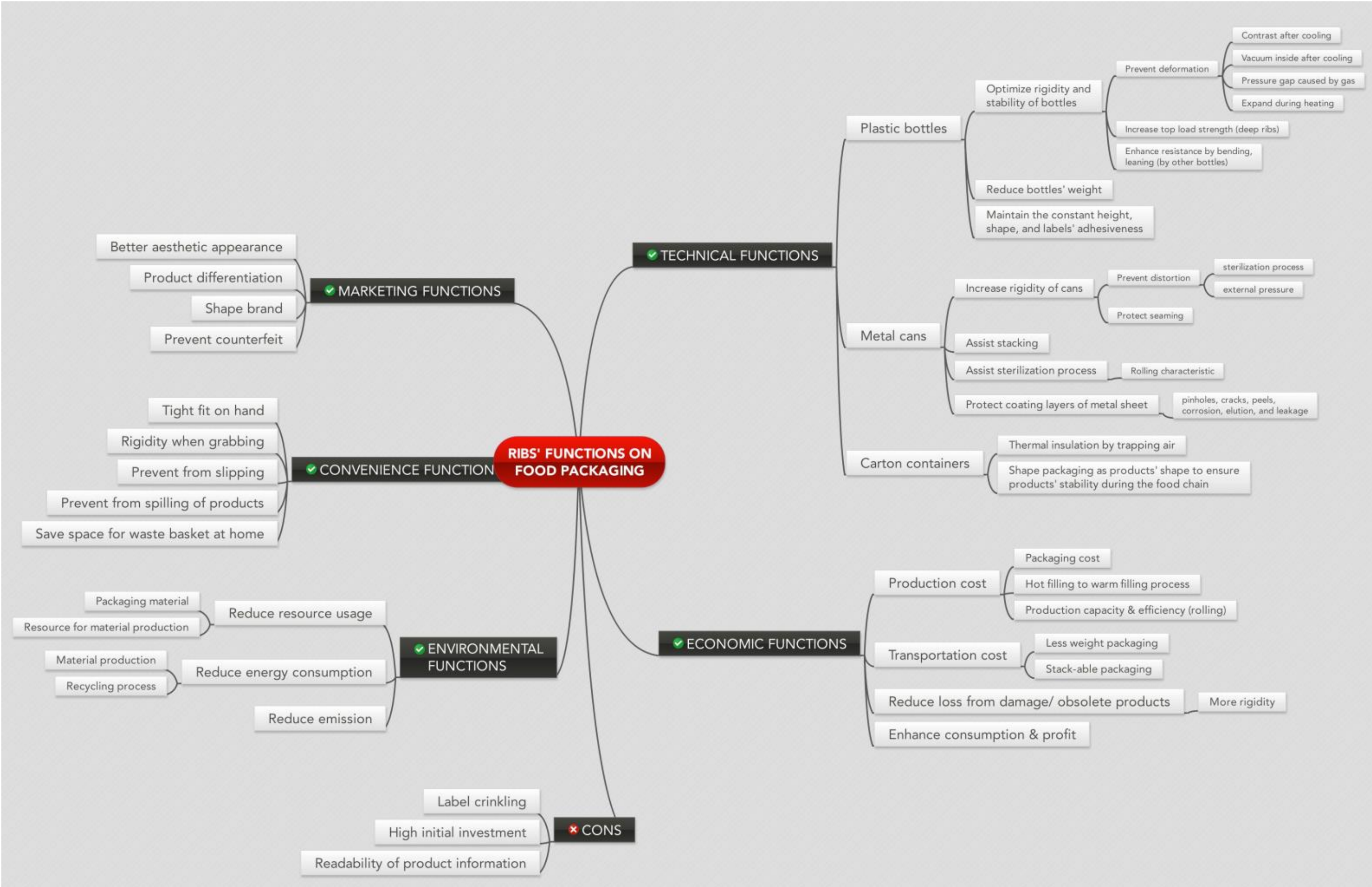

Figure 75: The map of ribs' functions on food packaging

5.2 Potential designs of ribs on Tetra Pak carton containers

From the findings regarding the functions of rib designs and the findings regarding consumer perception toward rib designs, ten rib design concepts are proposed for Tetra Pak carton containers to achieve multifunctional packaging.

The rib design concepts are built on both the thorough understanding of the Swedish consumers' perception and the ribs' functions on existing rib designs of other food packaging. Even though the researched Swedish consumers showed their preferences toward only three rib designs on carton containers, their behaviour and answers for the exploratory questions revealed more about their in-depth needs and preference that the consumers did not mention. Based on this in-depth understanding, the rib design concepts are developed in various ways that satisfy the consumers not only by aesthetic appearance but also by facilitating the consumers' needs. In addition, the proposal of rib design concepts for Tetra Pak carton containers also includes (1) which types of carton containers ribs should be applied to and (2) specific concepts of ribs to fulfil the consumers' demands. Six pillars used to build ten rib design concepts are visualized in Figure 76.

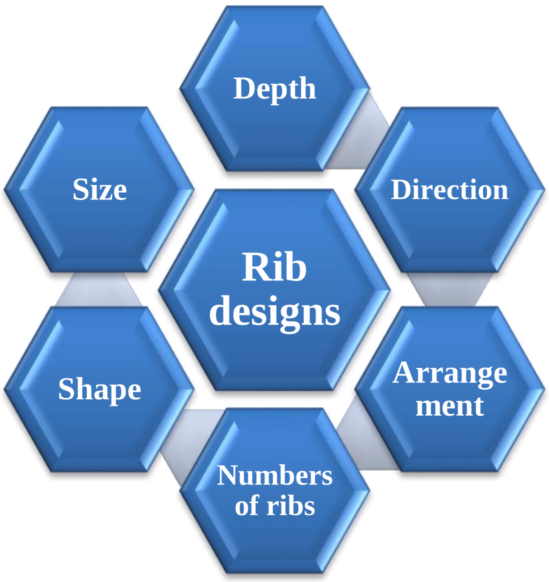

Figure 76: Six pillars of ribs design concepts

Last but not least, insights into purchasing drivers of Swedish consumers provide Tetra Pak with information about how to avoid the disadvantage of ribs and successfully approach its target consumers.

In order to visualize the proposed rib design concepts on Tetra Pak carton containers, some prototypes are built up in collaboration with the carton package development team at Tetra Pak Italy.

The proposed rib designs are the answer for the third research question (Q3) “Which design concepts of ribs can be suggested for Tetra Pak carton containers?”

5.3 Future work

Based on the findings of this research, it is proposed to create functional prototypes of carton packages with ribs. Once the findings of this research are verified on the prototypes, a feasibility study for industrial production of cartons with ribs should be launched.

In addition, in order to draw a concrete conclusion on the perception of Swedish consumers, it is proposed to conduct consumer research on general Swedish consumers in different big cities in Sweden, e.g. Stockholm, Gothenburg, Malmo. The selection of consumers’ attributes including gender, age, working area, income, and educational level should be ideally based on the Swedish demographics. Moreover, some rib designs on carton containers should be tested on these consumers to determine the most favourite rib design for carton containers from Swedish consumers’ viewpoint. Thanks to that, it might enhance the success ratio of new carton containers with ribs on the Swedish market.

In the case packaging companies have already identified target consumers, they should test rib designs directly on their target consumers. Thanks to that, the perceived results can represent for the perception and expectation of their target consumers. Consequently, these results can help to develop a specific rib design to approach their target consumers.

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APPENDICES

APPENDIX A: QUESTIONAIRE OF THE FIRST CONSUMER RESEARCH

"CONSUMER RESEARCH OF RIB DESIGNS ON CARTON CONTAINERS, PLASTIC BOTTLES, AND METAL CANS"

1> Gender: F M

2> Country of residence: Sweden Others (please specify):

3> Working area:

☐ R&D	☐ Administrator	☐ Customer Service
☐ HSE	☐ Human Resources	☐ Finance
☐ Sale & Marketing	☐ Production	☐ Others:
☐ Maintenance	☐ I.T. (Information Technology)	

4> Age: <20 20-30 31-40 41-50 51-65 >65

5> Two cans: a- with ribs, b-without ribs but paper label. **HOLD** them. Which one do you prefer?

a. b.

6> **READ** information on two cans, which can is easier to read information?

a. b.

7> 3 plastic bottles (A-No rib, B- Horizontal ribs, C- Vertical ribs), which design do you like most?

A B C

8> 2 bottles, same liquid and volume, a bottle you like is 11Kr, a bottle you do not like is 10kr, which one do you buy?

11kr 10kr

9> 4 bottles: Reference- no ribs, D- Straight line ribs, E- Embossed triangular shape ribs, F- Wavy ribs

Which design do you like most among D, E, and F?

D E F

10> **ACTION**: Please **hold** 3 bottles **BY 1 HAND** & pour a cup of water from them.

Which bottle is the easiest one for you to handle?

A B C

Why is it easier to handle?

11> 2 bottles, same liquid and volume, a bottle you choose is 17Kr, a bottle you do not choose is 16kr, which one do you buy? DO NOT CARE SHAPE/ DESIGN

16kr 17kr

12> 6 samples of ribs' feature on cartons, could you choose 2 most preferred designs of ribs? List by order of liking.

The most preferred one $\boxed{}$

The 2nd preferred one $\boxed{}$

13> 2 packaging contain same product, same volume.

One with ribs (I) is better for environment than a normal packaging (II).

The price of package I is 12kr. The price of package II is 11kr. Which one you buy?

11kr 12kr

APPENDIX B: QUESTIONAIRE OF THE SECOND CONSUMER RESEARCH

"CONSUMER RESEARCH OF RIB DESIGNS ON PLASTIC BOTTLES AND METAL CANS"

1> Gender: F M

2> Country of residence: Sweden Others (please specify):

3> Working area:

☐	R&D	☐	Administrator	☐	Customer Service
☐	HSE	☐	Human Resources	☐	Finance
☐	Sale & Marketing	☐	Production	☐	Others:
☐	Maintenance	☐	I.T. (Information Technology)		

4> Age: <20 20-30 31-40 41-50 51-65 >65

5> Two cans: a- with ribs, b-without ribs but paper label. **HOLD** them. Which one do you prefer?

a. b.

6> **READ** information on two cans, which can is easier to read information?

a. b.

7> 3 plastic bottles (A-No rib, B- Horizontal ribs, C- Vertical ribs), which design do you like most?

A B C

8> 2 bottles, same liquid and volume, a bottle you like is 11Kr, a bottle you do not like is 10kr, which one do you buy?

11kr 10kr

9> 4 bottles: Reference- no ribs, D- Straight line ribs, E- Embossed triangular shape ribs, F- Wavy ribs

Which design do you like most among D, E, and F?

D E F

10> **ACTION**: Please **hold** 3 bottles **BY 1 HAND** & pour a cup of water from them.

Which bottle is the easiest one for you to handle?

A B C

Why is it easier to handle?

11> 2 bottles, same liquid and volume, a bottle you choose is 17Kr, a bottle you do not choose is 16kr, which one do you buy? DO NOT CARE SHAPE/ DESIGN

16kr 17kr

12> 2 packaging contain same product, same volume.

One with ribs (I) is better for environment than a normal packaging (II).

The price of package I is 12kr. The price of package II is 11kr. Which one you buy?

11kr 12kr

APPENDIX C: TABLE OF χ2 VALUE VS $\boldsymbol{\rho}$-VALUE

Degrees of freedom (df)	χ^2 value[18]										
1	0.004	0.02	0.06	0.15	0.46	1.07	1.64	2.71	3.84	6.64	10.83
2	0.10	0.21	0.45	0.71	1.39	2.41	3.22	4.60	5.99	9.21	13.82
3	0.35	0.58	1.01	1.42	2.37	3.66	4.64	6.25	7.82	11.34	16.27
4	0.71	1.06	1.65	2.20	3.36	4.88	5.99	7.78	9.49	13.28	18.47
5	1.14	1.61	2.34	3.00	4.35	6.06	7.29	9.24	11.07	15.09	20.52
6	1.63	2.20	3.07	3.83	5.35	7.23	8.56	10.64	12.59	16.81	22.46
7	2.17	2.83	3.82	4.67	6.35	8.38	9.80	12.02	14.07	18.48	24.32
8	2.73	3.49	4.59	5.53	7.34	9.52	11.03	13.36	15.51	20.09	26.12
9	3.32	4.17	5.38	6.39	8.34	10.66	12.24	14.68	16.92	21.67	27.88
10	3.94	4.87	6.18	7.27	9.34	11.78	13.44	15.99	18.31	23.21	29.59
P value (Probability)	0.95	0.90	0.80	0.70	0.50	0.30	0.20	0.10	0.05	0.01	0.001

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APPENDIX D: DETAILED CHI-SQUARE CALCULATIONS

Table D1: The statistical calculation of consumer's perception toward the handle-ability of ribs on cans between the two groups

	Ribbing can	**Non-ribbing can**	**Total**	**Critical value**	**Chi-square χ^2**
Group 1 (O)	26	24	50	3.84 (at α = 0.05)	**0.16**
Group 1 (E)	25.0	25.0			
Statistics of Group 1	0.04	0.04			
Group 2 (O)	24	26	50		
Group 2 (E)	25.0	25.0			
Statistics of Group 2	0.04	0.04			
Total	50	50	100		

Table D2: The statistical calculation of consumer's perception toward the handle-ability of ribs on cans between the two genders

	Ribbing can	**Non-ribbing can**	**Total**	**Critical value**	**Chi-square χ^2**
Female consumers (O)	28	22	50	3.84 (at α = 0.05)	**1.44**
Female consumers (E)	25.0	25.0			
Statistics of Female	0.36	0.36			
Male consumers (O)	22	28	50		
Male consumers (E)	25.0	25.0			
Statistics of Male	0.36	0.36			
Total	50	50	100		

Table D3: The statistical calculation of consumer's perception toward the readability of ribs on cans between the two groups

	Ribbing can	**Non-ribbing can**	**Total**	**Critical value**	**Chi-square χ^2**
Group 1 (O)	1	49	50	3.84 (at α = 0.05)	**0.34**
Group 1 (E)	1.5	48.5			
Statistics of Group 1	0.167	0.005			
Group 2 (O)	2	48	50		
Group 2 (E)	1.5	48.5			
Statistics of Group 2	0.167	0.005			
Total	1	49	100		

Table D4: The statistical calculation of consumer's preference toward rib's direction on plastic bottles between the two groups

	Non-ribbing (A)	**Horizontal rib (B)**	**Vertical rib (C)**	**Total**	**Critical value**	**Chi-square χ^2**
Group 1 (O)	1	21	28	50	3.84 (at α = 0.05)	**3.36**
Group 1 (E)	3.0	18.5	28.5			
Statistics of Group 1	1.333	0.338	0.009			
Group 2 (O)	5	16	29	50		
Group 2 (E)	3.0	18.5	28.5			
Statistics of Group 2	1.333	0.338	0.009			
Total	6	37	57	100		

Table D5: The statistical calculation of consumer's preference toward rib's shape on plastic bottles between the two groups

	Straight line ribs (D)	**Rectangular shape ribs (E)**	**Wavy ribs (F)**	**Total**	**Critical value**	**Chi-square χ^2**
Group 1 (O)	8	10	32	50	3.84 (at α = 0.05)	**0.66**
Group 1 (E)	8.0	8.5	33.5			
Statistics of Group 1	0.000	0.265	0.067			
Group 2 (O)	8	7	35	50		
Group 2 (E)	8.0	8.5	33.5			
Statistics of Group 2	0.000	0.265	0.067			
Total	16	17	67	100		

Table D6: The statistical calculation of consumer's perception toward the convenience function of ribs on plastic bottles between the two groups

	A- a non-ribbing bottle	**B- a deep rib bottle**	**C- a shallow rib bottle**	**Total**	**Critical value**	**Chi-square χ^2**
Group 1 (O)	1	40	9	50	3.84 (at α = 0.05)	**3.39**
Group 1 (E)	2.0	36.0	12.0			
Statistics of Group 1	0.500	0.444	0.750			
Group 2 (O)	3	32	15	50		
Group 2 (E)	2.0	36.0	12.0			
Statistics of Group 2	0.500	0.444	0.750			
Total	4	72	24	100		

Table D7: The statistical calculation of the impact of packaging's aesthetic appearance to consumers' purchasing decision between the two groups

	Pay more for better aesthetic appearance	**Not pay more** for better aesthetic appearance	**Total**	**Critical value**	**Chi-square χ^2**
Group 1 (O)	27	23	50	3.84 (at α = 0.05)	**2.58**
Group 1 (E)	23.0	27.0			
Statistics of Group 1	0.696	0.593			
Group 2 (O)	19	31	50		
Group 2 (E)	23.0	27.0			
Statistics of Group 2	0.696	0.593			
Total	46	54	100		

Table D8: The statistical calculation of the impact of packaging's aesthetic appearance to consumers' purchasing decision between the two genders

	Pay more for better aesthetic appearance	**Not pay more** for better aesthetic appearance	**Total**	**Critical value**	**Chi-square χ^2**
Female consumers (O)	21	29	50	3.84 (at α = 0.05)	**0.644**
Female consumers (E)	23.0	27.0			
Statistics of Female	0.174	0.148			
Male consumers (O)	25	25	50		
Male consumers (E)	23.0	27.0			
Statistics of Male	0.174	0.148			
Total	46	54	100		

Table D9: The statistical calculation of the impact of packaging's convenience function to consumers' purchasing decision between the two groups

	Pay more for convenience function	**Not pay more** for convenience function	**Total**	**Critical value**	**Chi-square χ^2**
Group 1 (O)	29	21	50	3.84 (at α = 0.05)	**0.04**
Group 1 (E)	28.5	21.5			
Statistic of Group 1	0.009	0.012			
Group 2 (O)	28	22	50		
Group 2 (E)	28.5	21.5			
Statistic of Group 2	0.009	0.012			
Total	57	43	100		

Table D10: The statistical calculation of the impact of packaging's convenience function to consumers' purchasing decision between the two genders

	Pay more for better convenience function	**Not pay more** for better convenience function	**Total**	**Critical value**	**Chi-square χ^2**
Female consumers (O)	25	25	50	3.84 (at α = 0.05)	**1.999**
Female consumers (E)	28.5	21.5			
Statistics of Female	0.430	0.570			
Male consumers (O)	32	18	50		
Male consumers (E)	28.5	21.5			
Statistics of Male	0.430	0.570			
Total	57	43	100		

Table D11: The statistical calculation of the impact of the sustainable environment related function to consumers' purchasing decision between the two groups

	Pay more for environment related function	**Not pay more** for environment related function	**Total**	**Critical value**	**Chi-square χ^2**
Group 1 (O)	41	9	50	3.84 (at α = 0.05)	**0**
Group 1 (E)	41.0	9.0			
Statistic of Group 1	0.000	0.000			
Group 2 (O)	41	9	50		
Group 2 (E)	41.0	9.0			
Statistic of Group 2	0.000	0.000			
Total	82	18	100		