FEDERAL UNIVERSITY OF SÃO CARLOS

CENTER FOR EXACT SCIENCES AND TECHNOLOGY

PROFESSIONAL GRADUATE PROGRAM IN PRODUCTION ENGINEERING

ATTRIBUTES FOR SPARE PARTS PACKAGING: A KANO APPROACH

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MASTER'S DISSERTATION

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Attributes for spare parts packaging: a Kano approach

Dissertation presented to the Professional Graduate Program in Production Engineering at the Federal University of São Carlos (UFSCar), as part of the requirements for obtaining the professional master's degree in Production Engineering.

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SÃO CARLOS-SP

2024

FEDERAL UNIVERSITY OF SÃO CARLOS
CENTER FOR EXACT SCIENCES AND TECHNOLOGY
Professional Graduate Program in Production Engineering

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ACKNOWLEDGEMENTS

Expresso meus sinceros agradecimentos aos que foram fundamentais durante meu percurso no mestrado. Primeiramente a minha amada esposa Aline, que sempre me ofereceu apoio e encorajamento. À Dra. Fabiane, minha orientadora, meus sinceros agradecimentos pela sua valiosa contribuição, sábia orientação e palavras de motivação. Fabí, seu trabalho é verdadeiramente inspirador, e tive a honra de aproveitá-lo num momento tão especial para sua família, ao som da adorável Elisa. Aos estimados membros da Banca, Dra. Leda e Dr. Lauro, agradeço por aceitarem este convite e pela contribuição valiosa na melhoria do trabalho. Ao meu irmão Vi, agradeço pela paciente revisão textual e sugestões precisas, elas foram fundamentais para qualidade final da dissertação. Aos meus pais, Edna e Waine, dedico um profundo agradecimento pelo amor incondicional e pela educação que proporcionaram. Vocês são a inspiração que sustenta minha jornada. Por fim, aos amigos que caminharam comigo ao longo deste mestrado, seja na UFSCar ou na empresa, agradeço por compartilharem seus conhecimentos e risadas.

RESUMO

A disponibilidade de peças de reposição é uma questão crucial para o pós-venda automotivo. Cada peça de reposição, desde um simples parafuso até uma porta, é embalada individualmente, e essa embalagem deve ir além de simplesmente envolver o produto. O objetivo desta dissertação é identificar atributos de embalagem de peças de reposição e, posteriormente, determinar atributos-chave de embalagens primárias do ponto de vista de um fabricante de automóveis no Brasil. Isso foi feito por meio da revisão da literatura sobre atributos de embalagem, da classificação dos atributos por especialistas e da condução de uma pesquisa com representantes dos concessionários usando o Modelo Kano. Entrevistas adicionais com o Especialista em Desenvolvimento de Embalagens aprofundaram a discussão sobre os resultados. Esta pesquisa recomenda priorizar todos os seguintes atributos de qualidade obrigatórios para embalagens primárias de peças de reposição: 'Proteção e preservação', 'Facilitar o manuseio e distribuição', 'Caber com facilidade em espaços de armazenamento', 'Fácil de descartar e reciclar', 'À prova de vazamentos' e 'Utilização higiênica e segura'. Além disso, os atributos de embalagem devem ser suficientemente competitivos em dois atributos unidimensionais: 'Ser empilhável' e 'De baixo custo'. Por fim, na categoria de atributos atrativos o 'Uso de material reciclado' e 'Medidas ou dispositivos antifurto' podem ser destacados para surpreender os clientes. Para a empresa pesquisada, a embalagem primária de peças de reposição deve priorizar a proteção, eficiência na distribuição e sustentabilidade. Esses atributos, localizados nas dimensões Técnica e Funcional, servem como necessidades básicas de embalagem primária para peças de reposição. Ao recomendar os atributos-chave, esta pesquisa contribui para a assertividade no desenvolvimento de embalagens e apresenta um produto técnico: um relatório técnico conclusivo para embalagem de peças de reposição.

Palavras-Chave: Peças de reposição automotivas. Embalagem. Atributos de qualidade. Modelo Kano.

ABSTRACT

Spare parts availability is a crucial issue for automotive after sales and customer service. Every spare part, from a single bolt to a door is individually packed, and that packaging must do more than simply wrap the product. The aim of this dissertation was to identify spare parts packaging attributes, and thereafter, determine key primary packaging attributes from the perspective of an automotive manufacturer in Brazil. This was done by reviewing the literature for packaging attributes, ranking the attributes with specialists, and surveying customers representatives using a Kano approach. Additionally interviews with the Packaging Development Specialist deepen the discussion on the results. This research recommends prioritizing and fulfilling all Must-be quality attributes in spare parts primary packaging: 'Protection & preservation', 'Facilitates handling and distribution', 'Fits in storage spaces', 'Easy to recycle and dispose', 'Leakage proof', and 'Hygienic & safety'. Additionally, packing attributes should be competitive enough in two one-dimensional attributes 'Stackable' and 'Low cost'. Lastly, that attractive category 'Recycled material use' and 'Theft-prevention' should be given importance in packaging to delight the customers. For the researched company spare parts primary packaging should prioritize protection, distribution efficiency and sustainability. These attributes, residing in the Technical and Function dimensions, serve as basic packaging needs for spare parts. By recommending the key attributes this research contributes to packaging development assertiveness and presents a technical product: a conclusive technical report for spare parts packaging.

Key-words: Automotive Spare Parts. Packaging. Quality attributes. Kano Model.

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A – Attractive Quality Element

AC – Acceptable

DC – Distribution Center

DFMEA – Design Failure Mode and Effects Analysis

DI – Dissatisfaction Index

DNL – Do not like

FMEA – Failure Modes and Effects Analysis

I – Indifferent Quality Element

LK – Like

M – Must-be Quality Element

NF – No feeling

MB – Must-be

O – One-dimensional Quality Element

PE – Process efficiency

QFD – Quality Function Deployment

R – Reverse Quality Element

S – Skeptical Quality Element

SI – Satisfaction Index

WoS – Web of Science

CONTENTS

1 INTRODUCTION

Spare parts availability is a crucial issue for automotive after-sales and customer service. Every spare part, from a single bolt to a door is individually packed, and that packaging must do more than simply wrap the product. This chapter presents a background on the Brazilian spare parts market and discusses packaging interfaces with multiple areas. There seems to be a research gap in identifying key packaging attributes for spare parts within the Brazilian context. This research is a first step to fulfill this gap with inputs from spare parts specialists and dealership representatives of an automotive manufacturer.

1.1 BACKGROUND

Both automobile and motorcycle owners will need to replace a part or perform periodic maintenance during the product's useful life. In Brazil, automotive manufacturers have an after-sales market driven both by the demand for spare parts and by the Consumer Defense Code in article 32 (BRASIL, 1990)

> Art. 32. Manufacturers and importers must ensure the supply of components and spare parts until the manufacture or import of the product ceases.
> (…) Once production or imports cease, the offer must be maintained for a reasonable period of time, as provided by law (BRASIL, 1990, own translation)

The reasonable ‘period of time’ practiced by automotive manufactures is ten years of spare part supply counted from production or importation interruption (GOUVEIA, 2015).

The auto parts industry is divided in four sales channels. Assemblers represent automotive manufacturers. Aftermarket refers to products and services that are provided after the purchase of a product, such as replacement parts and periodic maintenance. Export represents sale or shipment of goods to another country. And the intrasectorial sales channel refers to trade or activity within other industry or sector (SINDIPEÇAS, 2023).

The estimated nominal revenue of the Brazilian auto parts industry in 2022 was R$ 233.7 billion, with 8.5% growth compared to 2021. Spare parts, included on the aftermarket sales, accounted for 19.0% of the auto parts industry's revenue as shown in Table 1, with an estimated nominal revenue of R$44.4 billion in 2022. This represents 10.8% growth compared to 2021 (SINDIPEÇAS, 2023).

Table 1 - Revenue by sales channel

	Assemblers	Aftermarket	Export	Intrasectorial
2017	62.8%	18.1%	12.8%	6.3%
2018	61.1%	17.7%	15.3%	6.0%
2019	64.4%	17.1%	13.2%	5.3%
2020	62.1%	19.4%	13.1%	5.4%
2021	63.4%	18.6%	12.9%	5.1%
2022	64.2%	19.0%	11.9%	4.9%

Source: adapted from Sindipeças (2023).

Spare parts departments from automobile manufacturers manage these spare parts by receiving parts from several suppliers, packaging parts individually and delivering them to dealerships based on customer orders. The automakers centralize and add value to parts before sending them to the distributors by packing then individually or and/or micro processing the parts.

According to McKinsey & Company (2021) the aftermarket reacted more quickly during the pandemic than other auto parts segments, achieving, in October 2020, an occupancy rate similar to the pre-pandemic level. The growth of the aftermarket is driven by the size and age of the fleet, and in a year of insecurity, maintenance has gained ground at the expense of new vehicle acquisitions.

Aftermarket services enable companies to gain an advantage over their competitors (COHEN *et al.*, 2006). The aftermarket contains market-oriented planning, control, realization, and design of the supply and distribution of spare parts (WAGNER; EISINGERICH, 2012). This involves demand and material planning, warehousing, packaging, and shipping (COHEN *et al.*, 2006). Spare part packaging plays an important role in assuring product quality maintenance during internal logistics, storage, picking, delivery and part use.

> Every spare part, from a single bolt to a door is individually packed, and that packaging must do more than simply wrap the product: it must cushion, cover and protect it from becoming damaged and broken while in storage and in transit (NAKAE, 2018, p.4)

Packaging's multiple functions and its logistics implication include product protection during distribution; shelf life and usage; efficient handling and storage, and communication (PAINE, 1990; RUNDH, 2005; EMBLEM, 2012).

Brazil's continental size require strategic distribution center placement and a wide dealer network to ensure spare parts are efficiently stored, managed, delivered at the right time, at the right quantity and quality for the end-user (automobile and motorcycle owners).

Auto parts dealers are businesses that sell original parts and accessories bought from directly from the manufacturer, through its Parts Division. These can include components, body parts, tires, and aftermarket upgrades. They also provide services such as installation, repair, and maintenance, supervised and oriented by the automotive manufacturer. Auto parts dealers receive packed parts from automotive manufacture and rely on packaging for product protection and identification.

Spare parts require packaging development for each of its new models and this represents around 3.500 parts for a new automobile and 2.500 parts for motorcycles according to the Spare Parts Division researched by this study.

In this case study research, the company subject of study is a motorcycle and automobile manufacturer located in Brazil since the 1970's. A Costumer Service division called Spare Parts Division handles packaging and nationwide distribution of spare parts, also working as a South America hub exporting parts overseas.

Spare Parts Division has tree distribution centers in Brazil with a total of 100 associates and a third-party logistics partner supported by 350 associates. There are more than 230,000 spare parts for cars and motorcycles distributed to 1,700 dealerships across the country aside from export operation.

A scientific approach is needed to understand spare parts packaging requirements and attributes, this may shift current spare parts packaging's development direction.

1.2 RESEARCH PURPOSE

The aim of this dissertation was to identify spare parts packaging features, and thereafter, determine key primary packaging attributes from the perspective of an automotive manufacturer in Brazil.

This was done through a case study by reviewing the literature for packaging functions, validating applicable packaging attributes with specialists, and determining key attributes with customers' representatives using the Kano model.

The result can, by providing recommendations, assist the Spare Parts Division in ensuring that their primary packaging attributes contribute to customer satisfaction.

Therefore, three research goals have been set:

a) To determine the relevant attributes of spare parts packaging;
b) To classify spare parts packaging attributes using a Kano Model approach, and;
c) To recommend spare parts packaging key quality attributes.

This dissertation contributes academically by applying the Kano Model on spare parts packing. Some research border this topic, but with a different scope (LÖFGREN; WITELL, 2005; RUNDH, 2005; DASH, 2021; PURBA *et al.*, 2018; SUNDESTRAND; SJÖSTRÖM, 2022; LIMA, 2009) as further discussed chapter 4.2.1. There seems to be a research gap in identifying key packaging attributes for spare parts within the Brazilian context. This research is a first step to fulfill this gap with inputs from spare parts specialists and dealership representatives of an automotive manufacturer in Brazil.

1.3 PROBLEM DESCRIPTION

The researcher wants to determine key primary packaging attributes from the perspective of an automotive manufacturer in Brazil. In a practical manner, this research may provide new insights for packaging development and will solve an internal issue regarding packaging expectations.

Since packaging has interfaces with multiple areas (quality, logistics, indirect material purchasing, product development, anti-counterfeit initiatives, marketing, branding, suppliers, and field operation) each area sees packaging through different lenses:

a) Quality focuses on part protection, anti-tampering and mandatory information;
b) Logistics is interested in storage and transportation efficiency;
c) Purchasing require low cost;
d) Product development encourages attractive packaging as long as it has a low cost;
e) Anti-counterfeit initiatives tend to add features that hinders piracy and allows product originality checks;
f) Marketing encourages attractive and innovative packaging;
g) Branding demands brand consistency and identity with a strong standardization directive;

h) Suppliers desire an easy-to-produce packaging with low diversity;
i) Field operation echoes customers' voices in a non-coordinated way (for example, some inputs are on quality direction and others in marketing direction).

Until now, Spare Parts Division has tried to balance all these in-house (internal clients) inputs in a Packaging Development Manual (PDM, 2020). The next step would be to validate those packaging attributes with a literature review crosscheck and then with costumer evaluation serving as powerful input for a more assertive packaging development.

In order to narrow the wide range of automobiles and motorcycle spare parts and its primary packaging, this study focuses on medium to large spare parts for automobiles and motorcycles that are externally visible. These parts, known as body parts according to the researched Spare Parts Division, are responsible for shaping the external structure of the vehicle. They play a crucial role in enhancing the vehicle's appearance, improving aerodynamics, and ensuring safety.

The main motorcycle body parts include frames, fuel tank, seat, fairing, fork, mirrors, front and rear fenders, instrument panel, headlights, taillights, exhaust system, wheels, tires, handlebars and footpegs.

The main car body parts include, bumpers (rear and front), bumper grille, cowl panel, crash guard, hood, floor, roof, tailgate, doors (left and right, rear and front), fenders, quarter panel, door handles, headlight, tail lights, fog lamps, indicator lights, airfoils, wheels, tires, mud flaps, mirrors, windshields (rear and front), side windows and quarter windows.

1.4 DISPOSITION

A summary about the structure of this dissertation is presented in Chart 1.

Chart 1 - Structure of this dissertation

Chapters	**Content**
1. Introduction	Provides a background to the context of the dissertation, presents the research purpose, and describes the problem.
2. Theoretical framework	Presents the findings of the review of literature regarding Packaging, Packaging Quality, and Kano Model, which is to be used in the analysis.
3. Research method	Describes how the thesis is performed. The research approach, how the data collection was done and the methods that were used. The data collection techniques used were surveys, internal document analysis and literature review.
4. Results and Discussion	In this chapter the findings of the data collection are presented. Packaging quality attributes are defined, and the Kano survey is performed. It also discusses relevant findings and reflections made from the empirical findings and theoretical framework.
5. Conclusion	Summarizes research's findings, practical and theoretical contributions are presented. Research limitations are discussed.

Source: Author.

2 THEORETICAL FRAMEWORK

Packaging materials are used in most everyday products ranging from commodities to retail products and high value equipment. This large range of use causes different points of view when trying to understand packaging functions. This chapter intends to present some of those packaging approaches. First by overviewing packaging characteristics such as different levels of packaging, materials, and basic specifications. Then, by discussing packaging interactions with warehousing and logistics operations. In order to uncover customer's perceptions towards packaging attributes a quality background is outlined together with the Kano Model. The Kano Model offers a useful method for classifying and comprehending customer requirements and their nature.

2.1 PACKAGING

As society migrated from rural areas to cities, food and commodities previously available locally now had to be transported to shops and began to be sold in the cities. This was strengthened by the Industrial Revolution, which began in England in the late seventeenth century, increasing demand for bags, barrels, and boxes to bring in supplies on a larger scale to factories as well as brought a need to supply goods in the small quantities now demanded by individuals and small families (EMBLEM, 2012).

> The move from packing goods at the point of sale to packing at the point of production brought about a shift from bulk to consumer packs, which had to survive the journey not just from shop to home, but, more importantly, from factory to shop, a journey which today may span countries and even continents and will include intermediate storage stages *en route* (EMBLEM, 2012, p.4).

This context helps to characterize what is currently understood as modern packaging. Packing consists of different combination of materials to protect the product against external factors from the place of production to the end-consumer, at least at its core:

a) 'Packaging is a coordinated system of preparing goods for transport, distribution, storage, retail sale and end use (PAINE, 1990, p. 5)';
b) 'Packaging is a means of achieving safe delivery in sound condition to the final user at a minimum overall cost (PAINE, 1990, p. 5)';
c) 'Packaging means all products made of any materials of any nature to be used for the containment, protection, handling, delivery and presentation of

goods, from raw materials to processed goods, from the producer to the user or the consumer (HÄNSCH; KINKEL, 1995, p.3)';

d) 'Packaging is the science, art and technology of enclosing or protecting products for distribution, storage, sale, and use (SIVARAMAN; VENKATESWARAN, 2022, p. 6)'.

As capitalism and competition between products and companies bloomed, a large range of goods began to be available at store's shelves and the packaging started to play a significant role in distinction between the available options from various companies and, different yet similar, types of products.

2.1.1 **Packaging functions**

> The basic function of all packaging is to identify the product and carry it safely through the distribution system to the final user. But packaging which is designed and constructed solely for this purpose adds little or nothing to the value of the product (PAINE, 1990, p.3).

Paine (1990) summarizes packaging as a coordinated system of preparing goods for transport, distribution, storage, retail sale, and end use. In addition, lists the most important functions of packaging. And those are containment, protection and preservation, communication, machinability, and convenience:

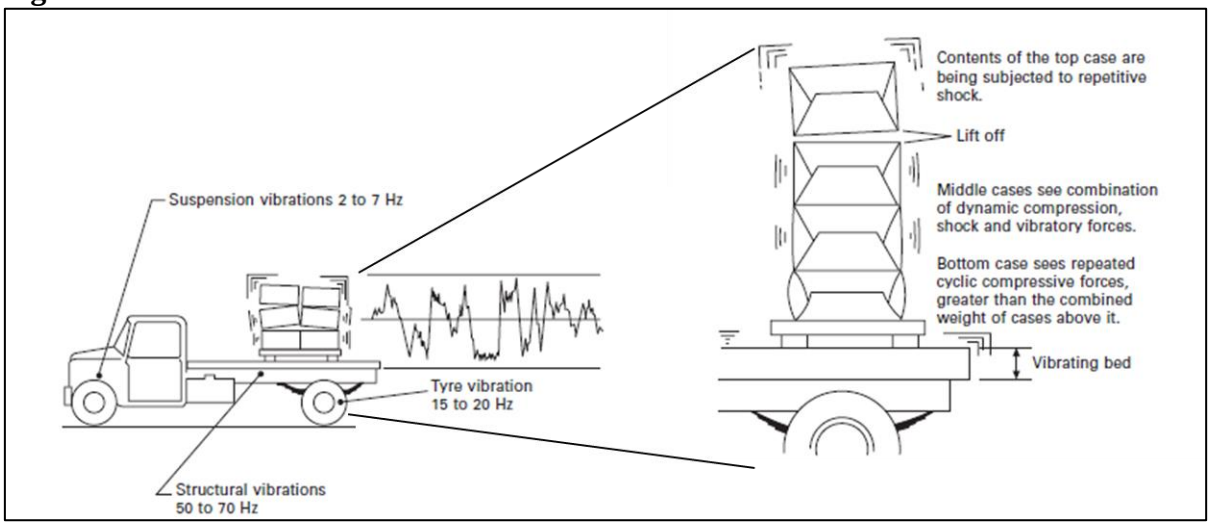
a) *Containment*: the packaging must hold the contents and keep them secure;
b) *Protection and preservation*: the packaging must protect the product from the mechanical and climatic hazards of the environment encountered during distribution and use;
c) *Communication*: retail packages must communicate, for not only do they have to identify the contents, but they must also assist in selling, using the product and indicate correct waste disposal;
d) *Machinability*: suitability and speed for the packaging line;
e) *Convenience and use*: the most common impression of convenience in terms of retail packaging is that of providing easy opening, dispensing and/or after-use. But both the shipping container and the retail package must provide

convenience at all stages, from the packaging line, through warehousing and distribution, to satisfying the needs of the consumer.

Properly designed, constructed, and sealed packaging is capable of providing a complete containment for the contents thus preventing leakage or loss of parts. Protection means the reduction of physical damage to the product, during all stages of its life. This includes manufacture and packaging operations, storage and handling in warehouses, transport to the merchant, distributor or store for sale, display, and moving to the final usage point (EMBLEM, 2012).

Emblem (2012) highlights that damage can occur at all handling stages, although most physical damage happens in the warehousing and distribution environment, due to dropping (from pallets, and during order picking and transit), jolting, vibration in vehicle (Figure 1), and compression (when stacked in warehouses) or puncturing (often due to use of poor-quality pallets).

Figure 1 - Sources of vibrations in road vehicles and stack resonance



Source: adapted from EMBLEM (2012).

There is a need for technical information on the identity of the product, its weight/volume, destination, handling, and possibly unpacking/repacking instructions. Nonetheless, that is not its only role. Packaging can also play the role of the ‘silent salesman’. This can be done by a combination of designs, branding, colors, graphics, shape and size of the packaging.

Rundh (2005) studies how packaging can contribute to competitive advantage, giving packaging a managerial focus by discussing 10 packaging functions:

a) Protection: packaging must be able to bear robust physical handling during distribution and stacking so that the goods are safely received by consumers;
b) Preservation: packaging characteristics can preserve product from deterioration;
c) Facilitates distribution: effective packaging ensure that goods reach their destination in optimum condition;
d) Promotes customer choice: enables and promotes brand identification and competition;
e) Sells: packaging is industry's silent salesman through visual appeal and product information;
f) Informs and instructs: packaging communicates additional messages to the consumer;
g) Provides consumer convenience: packaging may offer time-saving features and easy efficient handling;
h) Helps contain prices: various packaging sizes allows the consumer to purchase the most convenient quantity;
i) Promotes hygiene and safety: pre-packed medical products for usage and disposal;
j) Source of innovation: the packaging industry responds rapidly to new demands and lifestyles.

Kirwan (2013) summarizes packaging needs into three requirements:

a) Protection, preservation and containment of the product to meet the needs of the packaging operation and the proposed distribution and use within the required shelf life;
b) Efficient production of the packaging material, the pack in printing and converting, in packing, handling, distribution and storage, taking account of all associated hazards;
c) Promotion requirements of visual impact, display and information throughout the packaging, sale and use of the product.

Lindh *et al.* (2016) identified similar three clusters of packaging functions: protect, facilitate handling and communicate. They evaluate them based on their indirect contributions to sustainable development including:

a) Protection: decreased product waste, product quality maintenance and reduced risk for environmental and human health hazards.
b) Facilitate handling: increased handling, storing and transport efficiency increased recycling ratio.
c) Communicate: decreased product waste and packaging waste, increased recycling ratio, inform about content and/or package disposal.

Packaging that succeeds in fulfilling its functions can contribute to the environmental, social and economic dimensions of sustainable development in many ways. Because most of the features have several potential indirect effects, including decreased product waste, reduced risk for human health hazards, increased handling and transport efficiency (LINDH *et al.*, 2016).

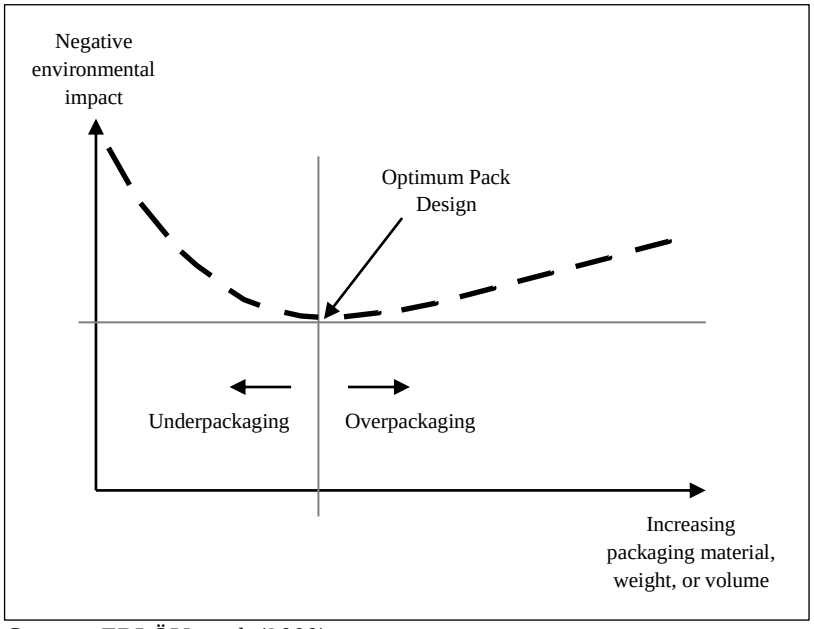
The development of sustainable packaging typically begins by focusing on the packaging material. It is important to choose the right material carefully in order to efficiently use materials with minimal environmental impact, while also ensuring adequate protection for the contents. However, there is no single packaging material that is always the most environmentally friendly, as this depends heavily on the specific product being packaged and its unique context.

Choosing the right packaging material can help to decrease the environmental impact of wasted products. There is a trade-off between how much material to use to keep the desired functionality, and how to ensure that the total resource utilization does not increase because of too much packaging material. This balance in food packaging is referred to as the Innventia Model. The model has been used to calculate the trade-off for various food items, revealing that the analysis of environmental impact must be highly contextual (LINDH *et al.*, 2016).

The Innventia Model for Optimum Packaging Design establishes a linear relationship between packaging material and packaging environmental performance either considering cost or waste as a performance indicator. The model explains that a good packaging design usually uses a minimum amount of material to perform its basic function until an optimum point is reached as shown in Figure 2. Beyond this point, any further reduction in packaging material raises the product losses in the supply chain. The environmental consequences of product losses caused by excessive reduction in packaging material are greater than adequate product

protection by excessive material usage. To avoid the sub-optimization, focus must be put on each stage in packaging life cycle that leads to holistic view of the system (ERLÖV *et al.*, 2000).

Figure 2 - Innventia Model for Optimum Packaging Design



Source: ERLÖV *et al.* (2000).

The European Organization for Packaging and the Environment acknowledges that the Innventia Model demonstrates the importance of a systematic approach addressing the entire packed product system is essential in order to ensure that individual improvements contribute to overall product sustainability (EUROPEN, 2009).

According to the Sustainable Packaging Coalition (2011) sustainable packaging is sourced responsibly, designed to be effective and safe throughout its life cycle, meets market criteria for performance and cost, is made using renewable energy, and once used through reverse logistics is recycled efficiently to provide a valuable resource for subsequent generations.

In addition to packaging's traditional function in product protection, it should be designed not only to differentiate the product, but also to facilitate and simplify all the logistic activities carried out along the chain, which can help to reduce the negative impact on the environment and society (GARCIA-ARCA *et al.*, 2017).

The packaging functions listed by Paine (1990), Rundh (2005), Kirwan (2013) and Lindh *et al.* (2016) are gathered in Chart 2. They agree on protection, preservation, distribution and process efficiency (PE), promotion, sells, and informs as packaging function.

Chart 2 - Packaging Functions

Packaging Functions	Paine (1990)	Rundh (2005)	Kirwan (2013)	Lindh *et al.* (2016)
Protection	x	x	x	x
Preservation	x	x	x	x
Containment	x		x	x
Distribution & PE	x	x	x	x
Promotion	x	x	x	x
Sells	x	x	x	x
Informs	x	x	x	x
Convenience	x	x		x
Right size & quantity		x		x
Hygienic & Safety		x		x
Innovation		x		
Sustainability				x

Source: Author.

Packaging materials are used in most everyday products ranging from commodities (for example grains, oil, and food) to retail products and high value equipment like notebooks and smartphones. Understanding the products peculiarity and its costumer's needs is the key to strategic packaging and more important than trying to stablish a generic and inflexible list of functions to be followed.

2.1.2 **Levels of packaging**

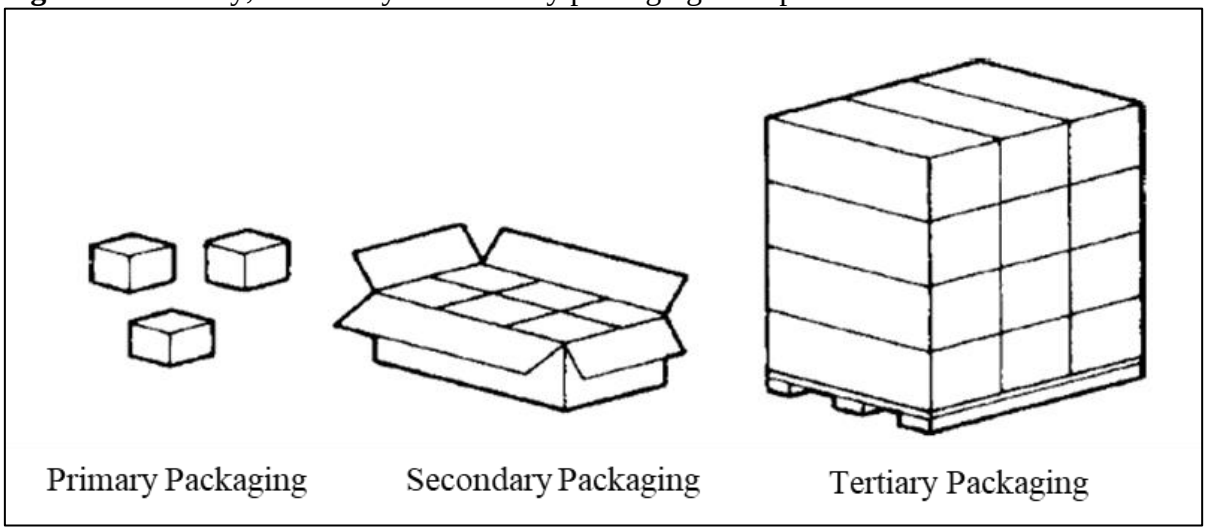
Throughout this text, three different levels of packaging are considered: primary, secondary, and tertiary. Based on Emblem (2012) and Kirwan (2013) the levels are defined as followed and illustrated on Figure 3:

a) *Primary packaging* includes materials in direct contact with the product that the consumer takes home. And once the product is used, eventually finding its way into the domestic waste stream. For example, beverage cans, a bag of chips or a computer box. Primary packaging is often referred to as 'consumer' or 'sales packaging';
b) *Secondary packaging* is used to group packaging together for the ease of handling. Collections of primary packs grouped for storage and distribution, wholesaling and 'cash and carry', for example transit trays and cases. Examples of secondary packaging are shrink-wrap film, and the corrugated board and thermoformed plastic trays used for shelf-ready packaging.

Secondary packaging may be called ‘group packaging’, ‘transport packaging’, ‘industrial packaging’ or ‘distribution packaging’.

c) *Tertiary packaging* is used to group secondary packs for ease of transport. The most common form of tertiary packaging is the pallet, along with stretchwrap film and a label to secure the secondary packs to the pallet and provide an easy means of identification. Roll cages, crates and heavy-duty fiberboard packaging (especially for export purpose) are also examples of tertiary packaging loads for distribution in bulk, for example.

Figure 3 - Primary, Secondary and Tertiary packaging examples



Source: adapted from Kirwan (2013).

At each level, the packaging functions may have different approaches. Primary packaging, for example, normally has a larger communication and convenience appeal to the end user than secondary and tertiary packaging. Secondary packaging, for electronics, auto-parts and e-commerce, focus on the ease of handling as preparation for a fast storage and distribution, with low visual appeal. Tertiary packaging hardly ends up on end-user household; therefore, its focus is to efficiently contain a bulk of secondary packaging (EMBLEM, 2012).

2.1.3 **Packaging Materials**

Food and drink account for around 70% of packaging consumption, but other sectors such as healthcare, beauty products, chemicals, clothing, auto-parts, electrical and electronic equipment all need packaging to ensure they stay in an acceptable condition from manufacturer to consumer. To fulfil this wide range of products packaging make use of different materials and combination (EMBLEM, 2012).

The main materials used in packaging today are paper, glass, steel, aluminum, and plastics. Wood and textiles are still used to some extent, but they are steadily being replaced (PAINE, 1990). Table 2 describes packaging material characteristics, with examples and market share.

Table 2 - Packaging material characteristics, examples and market

	Characteristics[1]	**Examples[1]**	**2022 Market[2] ($ Billion / %)**
Plastic	Combination of polymers for specific properties Light weight Resistant to moisture, gases, fungi and bacteria Good heat insulation Flexible or rigid Recyclable when rigid and/or dependent of polymer combination	Films, Laminates and sheets, Bags, pouches, sachets, blisters, bottles, jars, pots and boxes, cushioning materials, caps and closures	$541 (47%)
Paper	Many grades and forms Easy combination with other material Used in boxes or carton as secondary packaging Can be converted to rigid packaging Maintains characteristics over a wide temperature range Recyclable	Wrapping papers, bags, cartons and corrugated	$391 (34%)
Metal	Strength for long distance transport Accepts tin or organic coating High quality surface for printing Can be electronically welded Can be hermetically sealed Not affected by heat or cold Impenetrable to light, moisture and odors Can be extracted from solid waste Valuable scrap and high recyclability rate	Cans and aerosols, barrels, kegs, crates or boxes, closures, laminates and foils	$163 (14%)
Glass	Transparent but can be colored Chemically inert High vertical compression strength High speed packaging lines Provides reseal ability Reusable and recyclable	Bottles, jars, vials and ampoules	$64 (6%)

Source: [1]Paine (1991) [2]Condere (2020).

According to Condere (2020), flexible packages are made up of plastic film, aluminum foil, paper or a combination of these materials. The flexible plastic packaging wraps and films segment contributed approximately over 19.9% to the total market share in 2019, being extensively used for food packaging applications because of their enhanced chemical resistance properties. Recyclability issues, such as difficulties of mechanical recycling, hinder their use by environmentally concerned consumers. Most polymer films are made of polyethylene, polypropylene, polystyrene, polyester and nylon. Flexible plastic packaging end market is concentrated on food and beverage (59%) and non-food retail (12%).

Rigid plastic packaging is projected to grow due to applications in industrial packaging solutions and has benefited from the growing popularity of single-serve packaging in the food and beverage segment. Food and beverages end market emerged as the largest segment in 2019 with 37%, followed by consumer goods (19%), and chemical industry (17.5%). The rigid plastic packaging industry is experiencing competition from flexible and sustainable packaging designs, but it is still expected to maintain steady growth in developing economies (CONDERE, 2020).

The beverages industry is driving the global glass packaging industry. The alcoholic beverages industry is responsible for majority of the glass packaging market, with 62% of the market share, followed by food (16%), and non-alcoholic beverages (10%). Glass packaging is a highly competitive market, due to the strong presence of major players worldwide and held down by the presence of substitute material. Returnable glass bottles are a cost-effective option for companies to deliver their products and capable of end-use down-cycled recycling (CONDERE, 2020).

The metal packaging market dominates the canned food market, which is growing steadily with the shift towards processed, frozen, and pre-prepared foods. The beverage sector is dominated by the use of aluminum and steel cans. Additionally, aerosol cans are witnessing increased adoption in the automotive, cosmetics, industrial and household care sectors. Aluminum cans have a higher recycling rate and more recycled content than competing package types and are recycled repeatedly in a true closed loop recycling process. Properties of aluminum material such as its lightweight, 100% recyclability, resistance to corrosion and durability make aluminum more acceptable in end use industries (CONDERE, 2020).

Liquid packaging cartons account for 42% of the paper and cardboard packaging end market, followed by corrugated boxes and carton boxes at 34%. The increased usage of e-commerce to buy the essentials, especially in developing countries such as India, is having a positive impact on the market. Additionally, due to the COVID-19, pandemic consumers are

further driven towards e-commerce. Corrugate paperboard packaging offers a versatile and cost-efficient method to protect, preserve, and transport a wide range of products, and environment-friendly appeal (CONDERE, 2020).

E-commerce packaging will gain ground within the packaging industry as online shopping grows rapidly; corrugated packaging is expected to dominate the sector with its stable structure and sustainable qualities. The pandemic has shifted consumers' inclination to look for new channels to make purchases with strong accelerations in e-commerce shipments and remote-delivery services (CONDERE, 2020).

2.1.4 **Paper Packaging**

The paper industry started to use wood pulp to make paper in the middle of the nineteenth century. Nowadays, paperboard is one of the major raw materials used in packaging. There are many applications for paperboard, from simple cartons to more complex board structures for liquid packaging. Because it can be combined with other materials to make packaging for the transport and protection of a wide variety of products, from food, heavy machine tools, and to delicate instruments. In addition to its containment and protective qualities, paperboard has at least one surface suitable for printing, which helped expand its use (PAINE, 1990).

Paper and paperboard-based packaging is widely used because it efficiently contains the products, protects from mechanical damage, preserves from deterioration, provides visual impact through graphical and structural designs at a cost-effectively price. Up to 40% of all packaging is based on paper and paperboard, making it the largest packaging material used, by weight. Paperboard packaging is found wherever goods are produced, distributed, marketed, and used. Due to the widespread uses of paper and paperboard, the quantifiable consumption of paper and paperboard per capita is used as an economic barometer, in other words, it is an indication of the standard of economic life (KIRWAN, 2013).

Paper and paperboard can be found in the packaging of both dry (coffee, sugar, tea) and frozen foods (ice cream), liquid foods and beverages (milk), chocolate and sugar confectionery, fast foods, fresh produce (fruits and vegetables), personal care and hygiene, pharmaceuticals, agriculture and military, engineering and electrical products, electronics, auto-parts and e-commerce (KIRWAN, 2013). Folding cartons and corrugated board are the two main categories of paper-based packaging and frequently used as spare parts packaging (PURBA, 2018; NAKAE, 2018; DHL, 2019; SUNDESTRAND; SJÖSTRÖM, 2022; FEDEX, 2023).

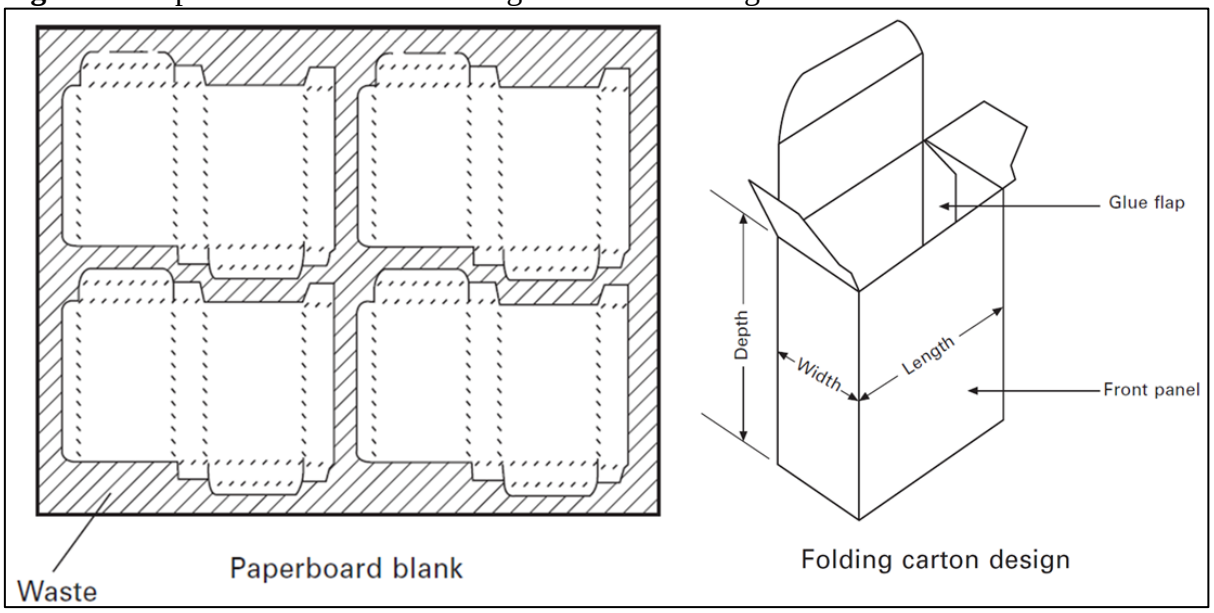
2.1.4.1 Folding Carton

Folding cartons are made from paperboard, often referred to as ‘cardboard’ or ‘cartonboard’. There are several different types of paperboards differing in the types of pulp used in their construction (KIRWAN, 2013).

Cartons are small to medium-sized boxes made from paperboard or in some instances paper (< 250 grams per square meter). Folding cartons are delivered to the packer in a flat form, who fills and closes the carton either manually, mechanically or by a combination of manual and mechanical means. According to Kirwan (2013) the flatness of the folding carton prior to the packaging operation is a major space-saving benefit in distribution and storage before use. The term folding cartons is usually applied to a package made from paperboard of thickness between 0.30 and 1.12 millimeters and delivered in a flat collapsed state (SIVARAMAN; VENKATESWARAN, 2022). A basic design of a folding carton is shown in Figure 4.

> Cartons are used for their protective and aesthetic properties, providing a very cost-effective means of packing products in a sustainable, recyclable material providing excellent graphics and presentation on shelf. They are, however, restricted in their preservation properties, as they possess poor gas and moisture vapor barrier properties, due mainly to the materials used and the integrity of the seal (EMBLEM, 2012, p. 222).

Figure 4 - Paperboard blank and folding carton basic design



Source: adapted from Emblem (2012).

The carton-making process consists of printing, cutting and creasing, window patching, and gluing. As the paperboard passes through all the printing presses, it is bent by the tension and feed rolls. This will break some of the fibers, reducing the stiffness and strength of the board. The main three print methods are: offset lithography, which is normally sheet fed, and gravure and flexography, normally reel fed (EMBLEM, 2012).

Cutting and creasing is done using a flat die for sheet-fed materials or a rotary die for reel-fed materials. The cutting and creasing operation (or box cutting) must be thoroughly done. If the cartons are not cut and creased correctly, their performance will be impaired during the stages of conversion, filling and distribution.

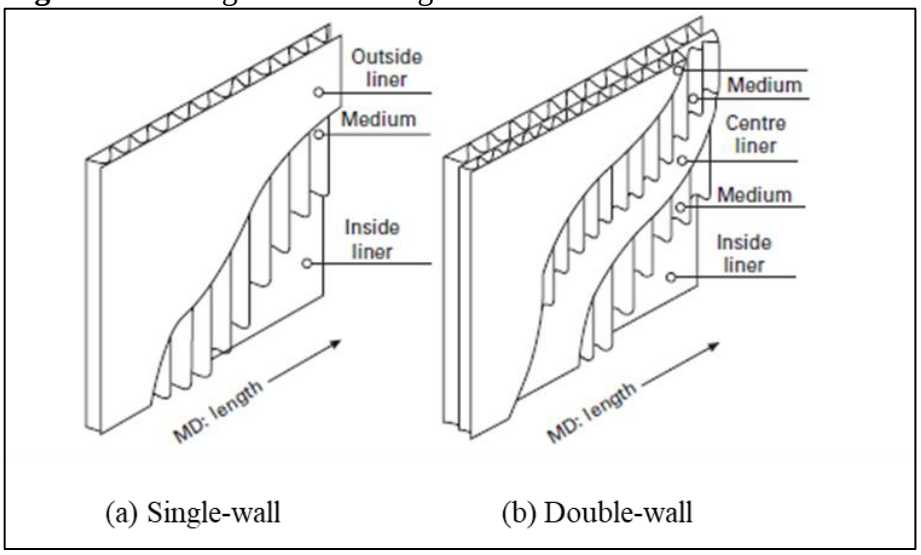
Cartons are cut and creased using a form. To enable the cutting and creasing operation to be controlled, a counter plate is placed on the base of the press, exactly in line with the form. Once the cutting and creasing operations have been completed, the cartons can, if required, be window patched (EMBLEM, 2012).

2.1.4.2 Corrugated Board

Corrugated fiberboard is the most popular packaging for storage and distribution of goods. Corrugated fiberboard is defined as two outside papers with a corrugated shaped paper in between. The outer papers are the liners and the corrugated shaped paper is known as fluting or medium. The use of two or three layers can increase its strength. Initially corrugated fiberboard was only used for the secondary or transport packaging, but with the introduction of micro-flutes and high-quality printing, it is also used for the primary packaging. Corrugated board is a light, high-performance material, with a flexible structure. The combined materials are designed to have a higher bending resistance than their individual components due to their created thickness (KIRWAN, 2013).

If only one liner is used, the product is called ‘single faced’. If two liners are used, one on either side of the fluting, the product is known as ‘single wall’. The combination of two flutings and three liners is called ‘double wall’ and the combination of three flutings and four liners is called ‘triple wall’, as shown on Figure 5 (KIRWAN, 2013).

Figure 5 - Corrugated board single-wall and double-wall



Source: Emblem (2012).

Single-wall is a standard type for most product types, double-wall are used for heavier or more bulky products such as machinery, large appliances or furniture, or for display stands, or for products which are stored for extended time periods. Triple-wall are used for particularly heavy-duty applications, for instance as a substitute for wooden containers for pallet boxes or bulk bins (EMBLEM, 2012).

There are three basic materials required for corrugated board: liner or facing materials, flute materials and adhesives. The facings can be made from Kraft paper (named after the chemical pulping process used to manufacture the paper) which has a high proportion of virgin fibers and added recycled papers (known as 'Test' materials). Kraft type paper is commonly used as the outer part of the box. The recycled papers are made from in-process waste and from post-consumer recycling. Varying amounts of recycled or secondary fiber are used for producing both liners and corrugating medium. Recycled board is made to the same specifications as virgin material, so that stiffness and burst values are similar, although it is slightly thicker to compensate for the weaker recycled fiber. Other properties will depend on the source and quality of the fiber. Recycled board typically has a somewhat smoother surface finish (and therefore better printability) and a lower coefficient of friction than virgin Kraft. On the other hand, recycled board absorbs water faster than Kraft, which could be important factor when used on high-humidity environment such as at overseas transportation. Water absorption on corrugate board reduces its the stacking properties, because corrugated board loses around 50% of its compression strength between 50 and 90% relative humidity (EMBLEM, 2012).

The fluting shape is formed using heat, moisture, and pressure from corrugated shaped rolls. Technically, any flute profile size can be used to make corrugated fiberboard. Historically

flute profile sizes are indicated with a single letter to define their pitch, the number of flutes per unit length and the take-up factor. The pitch is the distance between two fluting tips. The take-up factor defines the length of the fluting (medium) paper used in a corrugated fiberboard structure compared with the length of the liners. Corrugated board is normally made in one of the following flute types: K, A, C, B, E, F, G and O (Table 3). The most commonly used flute types are B, C and E (KIRWAN, 2013).

Table 3 - Flute profiles and board thickness

Flute type	Flute pitch (mm)	Board thickness (mm) including papers
K	12	6.5
A	9	5.0
C	8	4.2
B	6.5	3.0
E	3.5	1.7
F	2.4	1.2
G	1.8	1.0
O	1.25	0.7

Source: adapted from Kirwan (2013).

According to Kirwan (2013) using the same three papers, C flute gives a higher stacking strength than B flute and that B flute gives a higher stacking strength than E flute. More overall board thickness gives a higher stacking strength. Higher flutes are more effective with respect to paper consumption than low flutes. On the other hand, the print quality is better for flute with a lower pitch than with a higher pitch. Hence, E flute has a better print quality than B flute and B flute has a better print quality than C flute. There is a wide choice of papers for each liner and fluting. Like so many aspects of design, there is no one single best solution, it is a matter of optimizing the often-conflicting requirements and prioritizing them for a particular set of circumstances.

Emblem (2012) compares the characteristics of the main flute sizes and performance such as; staking strength, puncture resistance, cushion, crush and printing quality (Table 4). Confirming flute A as best for stacking and cushion and flute B best for puncture resistance.

Table 4 - Comparing characteristics of the main flute sizes

Flute	Flute Height (mm)	Flute per meter	Stacking strength	Puncture resistance	Cushion	Flat crush	Surface print quality
A	4.5 – 4.7	110	Best	Good	Best	Poor	Poor
C	3.5 – 3.7	129	Good	Best	Good	Fair	Fair
B	2.4 – 2.6	154	Fair	Fair	Fair	Good	Good
E	1.1 – 1.2	295	Poor	Poor	Poor	Fair	Very Good
F	0.7 – 0.8		Poor	Poor	Poor	Poor	Excellent
N	0.5		Poor	Poor	Poor	Poor	Excellent
G	0.4		Poor	Poor	Poor	Poor	Excellent

Source: adapted from EMBLEM (2012).

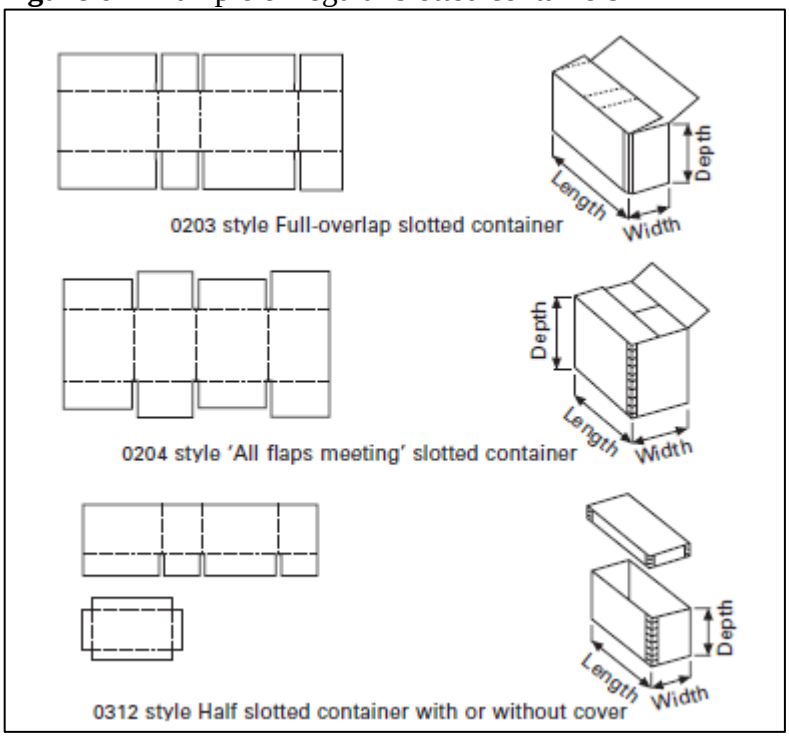
A-flute is used in cushion pads, heavy-duty boxes and the construction of triple-wall board grades where the added thickness is an advantage. However, use of A-flute has been in decline, because A-flute's almost 5-mm thickness occupies more space than C-flute and thus has significantly greater deflection before bearing load when compressed. C-flute has about 10% better stacking strength than the same board weights in B-flute. C-flute is sometimes chosen over B-flute for glass containment, despite C-flute's lower flat crush strength, the thicker flute will provide more puncture protection for the glass. B-flute is used for products where case-stacking strength is not required or where the distribution environment is very short. E-flute and smaller flutes (micro-flutes) are not generally associated with shipping containers, they are mostly used to replace carton board for heavier or special protective primary packs. There is a range of finer flutes such as F, G, N and T, which are specific to certain manufacturers and used when high-quality graphics are required. Double-walled or triple-walled constructions can have a combination of flute types, perhaps E or B on the outer wall and B or C flute on the inner, offering a flat surface for printing combined with a load bearing flute on the inner wall (EMBLEM, 2012).

Standard corrugated board is made with a starch-based adhesive applied at about 10 – 14 grams per square meter. Starch loses strength at high moisture levels, where higher resistance is needed, starches can be modified by adding various polymers or water-resistant adhesives. There are three main basic types of corrugated fiberboard: regular slotted containers, die-cut containers and multi-component designs (EMBLEM, 2012).

Regular slotted containers are the most common corrugated container (Figure 6), because it is economical to produce and makes efficient use of board. The basic design has four flaps of equal width, at the top and bottom, made from a rectangular blank. The outer flaps meet, while the inner flaps do not. As a result, parts of the top and bottom of the box have only a single layer of thickness of corrugated board (PAINE, 1990).

Regular slotted containers have straight lines and right-angle cuts of conventional scoring and slotting equipment. These packaging are easy to manufacture on standard machinery, the manufacturer simply sets the slotters and folder-gluers to the required dimensions (EMBLEM, 2012).

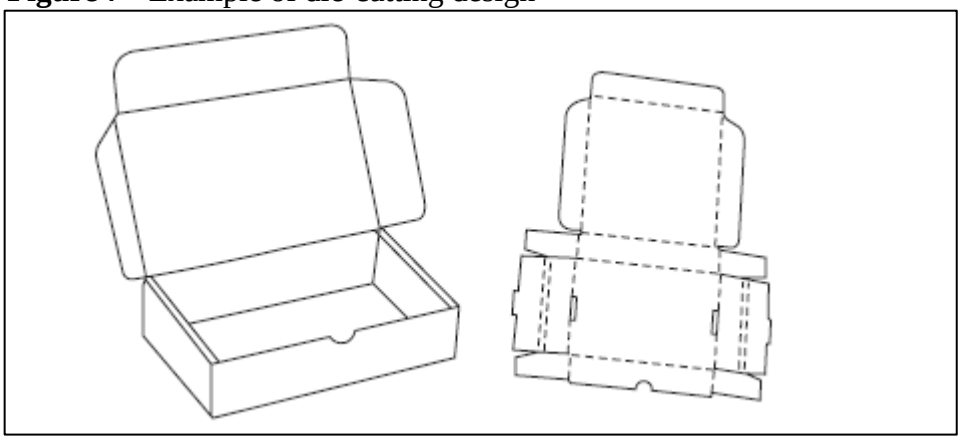
Figure 6 - Example of regular slotted containers



Source: Emblem (2012).

Die-cutting is used for more complex designs (Figure 7), because it is both more elaborate and die-cut containers are dimensionally more accurate than regular slotted containers. These are produced by platen presses that cut and score the board in a manner similar to that used in making folding boxboard cartons. Die cutting of corrugated blanks has traditionally been done on flatbed presses, while more recently rotary die cutters using cylindrical dies became popular because of greater productivity (PAINE, 1990).

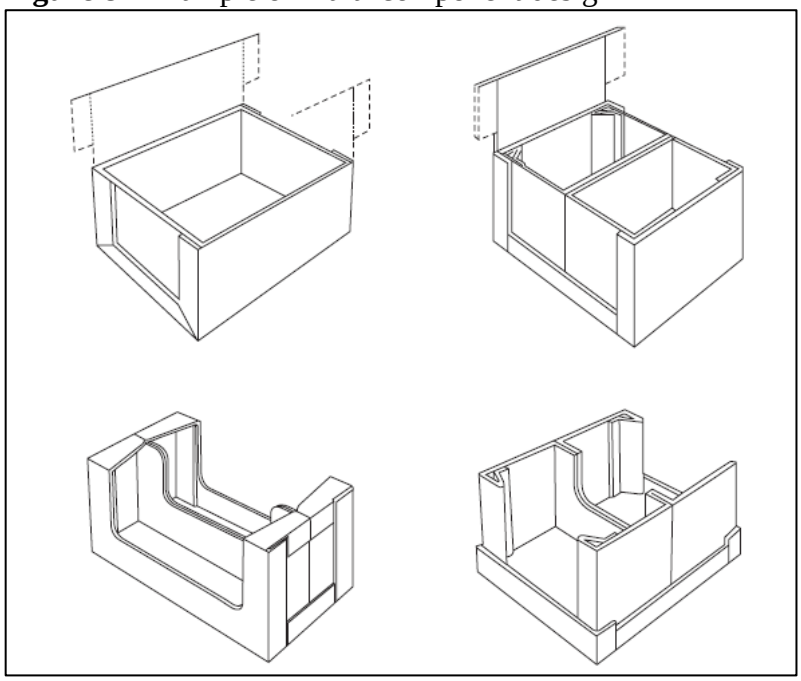
Figure 7 - Example of die-cutting design



Source: Emblem (2012).

A third design type defined as multi-component design is shown in Figure 8, they are assembled from a number of separate cut pieces, usually a body panel and two end panels, rather than from a single sheet. According to Emblem (2012) using individual cut pieces maximizes utilization of material and enhances compression strength. Other design variations include the incorporation of separate H partitions and triangular corner posts for greater strength.

Figure 8 - Example of multi-component design



Source: Emblem (2012).

2.2 WAREHOUSING

Warehousing became a key component in complex supply chains to help meet the service levels required by costumers, as they facilitate the movement of goods through the supply chain to the end consumer. They perform a range of crucial roles, such as buffering the material flow along the supply chain to compensate for variability brought on by factors such as product seasonality and/or batching during production and transportation; product consolidation from different suppliers; and value-adding processes including packing, pricing, labeling, and product customization (GU *et al.*, 2006). Activities performed in warehouse's processes are packaging-dependent, with several packaging touches and interactions during receiving, checking, storage, picking, and shipping (HELLSTRÖM; SAGHIR, 2006).

2.2.1 **Warehouse operations**

The main operations done by warehouses include receiving, storage, order picking, sortation, packing and dispatch.

Receiving involves unloading of incoming transport, checking invoices and purchase orders, quality control, and registering the incoming goods into a computer system. It may also include unpacking and repacking in a suitable format for the end consumer or warehouse operation, also known as inbound packaging (RUSHTON *et al.*, 2014).

Once ready for storage, goods are assigned to a free location on the storage area. This may be bins, shelves, modular storage drawers for small items, pallet racks, gravity flow racks, or mobile storage racks if the products are bulky or even on the floor. The use of software can help optimize storage by considering product's characteristics (dimensions, weight and special storage needs), ABC analysis and efficient picking route. The storage area can represent more than 50% of a floor area usage in a warehouse. This area holds the bulk of warehouse's inventory in identifiable locations (RUSHTON *et al.*, 2014).

When an order is received from a customer, goods need to be picked from the warehouse in the correct quantity and in time to meet the required service level; this is called order picking and is a very labor consuming activity when not automatized.

An order normally contains several order lines, each requesting a specific quantity of an individual product to be picked. If the order line is for a full unit load (for an example a pallet) then this can be retrieved directly from the reserve storage area and directly taken to the dispatch area, without further cartonization. However, if the order line is for less than a unit load (for

example a number of packages or items) then the goods will normally be retrieved from the picking location and taken for the packing (or cartonization) area. Order picking is a key warehouse operation, both in terms of cost and service, because a significant proportion of the warehouse staff is normally dedicated to this function and because it is critical to achieving high levels of order accuracy. Defining the best picking strategy by optimizing routes and equipment use, picking by voice or with help of augmented reality, the use of treadmills, shuttles, automated guided vehicles, and/or combining packing during picking are examples of initiatives aiming at improving picking efficiency (RUSHTON *et al.*, 2014).

For orders of small size, it is sometimes appropriate to batch several orders together and treat them as 'one' order for picking purposes. In this case, the picked batch will have to be sorted down to individual orders before dispatch; this process is known as sortation. Unless the goods are picked directly into the dispatch containers (full unit loads), they will be assembled or packed together after picking. For example, the goods may require a secondary packaging where they are put into a carton, frequently knowns as outbound packing. These goods may be stretch or shrink-wrapped on to a wooden pallet ready for transit. This process may also involve final production postponement activities and value-added services, such as kitting and labelling (RUSHTON *et al.*, 2014).

During the shipping process goods are marshalled together to form vehicle loads in the dispatch area, sometimes known as the consolidation stage, and are then loaded on to outbound vehicles for onward dispatch (RUSHTON *et al.*, 2014). Shipping processing requires previous scheduling of the carrier, the placing of products on the shipping docks, and their loading into the mean of transport.

Gu *et al.* (2006) presents warehouse processes as:

a) *Receiving and shipping*: incoming shipments are brought to the warehouse, unloaded at the receiving docks, and put into storage. Orders are picked from storage, prepared, and shipped to customers through shipping docks;
b) *Storage*: storage deals with the organization of goods held in the warehouse in order to achieve high space utilization and facilitate efficient material handling;
c) *Order picking*: is generally recognized as the most expensive warehouse operation, because it tends to be either very labor intensive or very capital intensive. Managing the order picking process requires the organization of the orders to be picked and of the material handling operations of the picking and the selection of an order picking method;

d) *Sorting*: is required when multiple orders are picked together. It can be performed either during the picking process (sort-while-pick) or after the picking process (sort-after-pick).

To achieve a better service level some warehouse activities are continuously improved, such as: maximizing the warehouse storage utilization (occupation); maximizing the utilization of the warehouse equipment and warehouse staff; reducing product and packages handlings; maintaining required product accessibility through 5S (Sort, Set in Order, Shine, Standardize, Sustain). Thereby assuring product rotation or turns, reducing operating expenses, and assuring the protection of the warehouse's assets (TOSTAR; KARLSSON, 2008).

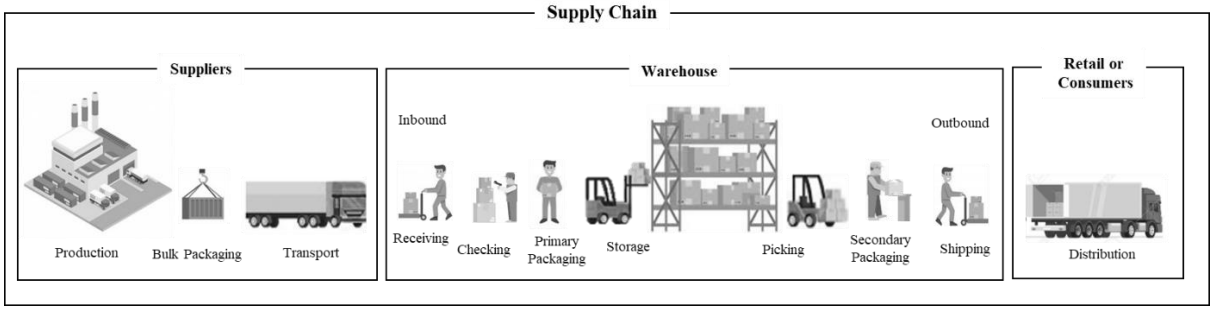
2.2.2 **Packaging interactions with warehousing and logistics operations**

Paine (1990) lists the fundamental functions of packaging as protecting, containing, preserving, and communicating the product. All products must be contained in order to provide easy handling, warehousing, and transport. Primary packaging is that in direct contact with the product, while secondary packaging is designed to contain several primary packages. An assembly of several primary or secondary packages on a pallet or a roll container is defined as tertiary packaging (EMBLEM, 2012).

These concepts should be applied with the understanding that packaging is a system with levels of hierarchy. The systems approach emphasizes the relationship between the various levels of packaging and makes it easier to comprehend their interdependence (HELLSTRÖM; SAGHIR, 2006).

A study done by Hellström and Saghir (2006) highlights that packaging engineers frequently overlook many packaging-dependent costs in the logistics system, despite the fact that packaging is known to have a significant impact on the effectiveness of logistics systems and activities like manufacturing, distribution, storage, and handling throughout the supply chain. Packaging specifications affect the time required for packaging operations, which ultimately affects product lead-time and due date performance to the customer. Packaging affects main logistics activities, such as transport, inventory, warehousing, and distribution, as illustrated on Figure 9.

Figure 9 - Packaging logistics interactions in the supply chain



Source: Author.

> From a system perspective, there are three areas where packaging-related improvements in the supply chain can be made: in the logistics process; in the packaging system; and in interactions between the two. Consequently, there is a need to focus on the interactions and not on the packaging system or the logistics processes separately (HELLSTRÖM; SAGHIR, 2006, p. 200).

The first step of the packaging journey through the retail supply chain begins in the filling process, at the packaging and filling machine. Here the product meets the primary packaging that will, in the long run, end up in households. Essentially, primary packing interacts with the manufacturer filling process and with retail and end-user during product use and disposal. The activity of filling/placing products into secondary packaging is adapted to quantity, speed and stability of the primary packaging. The choice of secondary packaging is a driver of customization and differentiation further down the retail supply chain. The size of the secondary packaging and the number of products it carries affect handling, transportation, warehousing, picking, and retailing (HELLSTRÖM; SAGHIR, 2006).

Palletizing should facilitate efficient handling, by improving stability and stacking. The level of stacking depends on the material and shape of the packaging. When palletizing, stability is gained by using lock pattern stacking. Shrink film is also used to increase the stability and to protect the products. According to Hellström and Saghir (2006) pallets are the main transport unit of the manufacturer.

Transport activities interact mainly with tertiary packaging (pallets and roll cages). Transport unit adaptability is considered the most important factor from an efficiency point of view. Stackability is also an important factor that directly affects transport costs. Weight and height of tertiary packaging are two limiting factors with constraints, which directly affect transport efficiency and cost. Pallet adaptability has a direct effect on volume and area efficiency in the transport vehicle (HELLSTRÖM; SAGHIR, 2006).

Most activities performed in warehouse's processes are packaging dependent as illustrated on Figure 9, with several packaging touches and interactions during receiving, checking, storage, picking, and shipping.

Hellström and Saghir (2006) state that labor generally represents the greatest cost in a warehouse, as there is an extensive amount of manual handling. The activities in the receiving process are unloading, application of labels and controlling the received products. Unloading often uses a pallet stacker, or is done automatically, using automated unloading equipment. Once the shipment has been unloaded, pallets are labelled and checked (HELLSTRÖM; SAGHIR, 2006).

Torn and smashed packages are often seen as sign of potential product damage (PURBA, 2018); in this case, the load is forwarded for quality check or returned to supplier.

In the storing process, the allocation of storage placement is fundamental, pallets and packages cubic dimensions are critical for an efficient storage. Order picking represents the core activity, and some packaging aspects influence the efficiency of the order picking activities such as quantity, weight, volume, and stackability. In some cases, a picking label is applied to a secondary packaging to help guarantee that all products have been picked. Picking efficiency is closely linked to considerations such as human factors, reward systems, order structure, warehouse layout, picking equipment, type of products picked, and the shape and type of packaging (HELLSTRÖM; SAGHIR, 2006).

Secondary packaging is done during picking or sorting stage to consolidate orders, check for picking accuracy and facilitate truck loading (GU *et al.*, 2006; RUSHTON *et al.*, 2014).

According to Hellström and Saghir (2006) the main packaging-related problems that occur in a warehouse are:

a) Pallet overhang due to stacking products outside the limits of the pallet;
b) Difficulty in stacking products in the roll container;
c) Ergonomic aspects (package size and weight, slippery packages, risk of cutting injuries on the edge of corrugated board and difficulties in getting a grip);
d) Missing handling aids, for an example grip handles;
e) Too-strong of an adherence between packaging layers on the pallet, and;
f) Too-fragile packages that open or break when handled.

Lambert *et al.* (1998) define some packaging trade-offs with other logistics activities (Chart 3), alongside other already discussed impacts on logistics, increased package protection

inhibits theft during storage and transportation as well as reduces damage to products. Accurate package information decreases tracking of lost shipments and reduces picking labor costs by rapidly identifying the correct product.

Chart 3 - Packaging trade-offs with logistics activities

Logistic activity	Trade-offs due to the increase of packaging characteristics
Transportation	
Increased package information	Decreases shipment delays; increased package information decreases tracking of lost shipments
Increased package protection	Decreases damage and theft in transit, but increases package weight and transport costs
Increased standardization	Decreases handling costs, vehicle waiting time for loading and unloading; increased standardization; increases modal choices for shipper and decreases need for specialized transport equipment
Inventory	
Increased product protection	Decreased theft, damage, insurance; increases product availability (sales); increases product value and carrying costs
Warehousing	
Increased package information	Decreases order filling time, labor costs
Increased product protection	Increases cube utilization (stacking) but decreases cube utilization by increasing the size of the product dimensions
Increased standardization	Decreases material handling equipment costs
Communications	
Increased package information	Decreases other communications about the product, such as telephone calls to track down lost shipments

Source: Lambert *et al.* (1998).

The packaging system must satisfy demands from a number of logistics and warehouse processes, including several packaging touches and movements. Recognizing the importance of these interactions stimulates efficient packaging design and may help to lowers damage rates or leverage other packaging functions.

2.3 THE KANO MODEL

In today's world, there is no single accepted definition of quality. Business-shifting needs have led to the creation of many quality definitions. In a comprehensive view, competition seems to have caused a general shift of interest from the producers' point of view (manufacturing-based quality, objective quality, and production management quality) towards perceived or subjective quality (LILJA, 2000). Quality has several definitions (DALE, 2003):

a) Uniformity of the product characteristics or delivery of a service around a nominal or target value;
b) Conformance to agreed and fully understood requirements, this definition is attributed to Crosby (CROSBY, 1979[1] apud DALE, 2003);
c) Fitness for purpose/use, first used by Juran (JURAN, 1988[2] apud DALE, 2003);
d) Satisfying customer expectations and understanding their needs and future requirements, requirements of total quality management;
e) Degree to which a set of inherent characteristics fulfils requirements, as an international definition of quality (ISO, 2015).

A value perspective taken further by Feigenbaum (1991) states that quality is about establishing a proper balance between the cost of the offer and the customer value it renders. Quality can be seen as the ability of a product or service to create value. According to Lilja (2010) most modern quality definitions, recognize that quality should be valued by the customers and always be put in relation to their needs and expectations. Dale (2003) supports this notion when stating that the focus of the quality definition is adding value. In this dissertation, quality is acknowledged as the 'ability to create value'.

Watson (2019) states that quality can be considered from two very different perspectives. Backward-looking quality aims to resolve product/service issues that have occurred in the past. These include defects that have been observed by customers, issues related to failure of the product/service to meet customers' expectations, and/or feedback associated with complaints. On the other hand, forward-looking quality focuses on creating positive value

[1] CROSBY, P. B. **Quality is Free**. New York: McGraw Hill, 1979. D. Van Nostrand Co. Inc, 1931.
[2] JURAN, J. M. (ed) **Quality Control Handbook.** New York: McGraw Hill, 1988.

by enhancing features that lead customers to believe that the resultant products/services are superior to other options available in the marketplace.

Backward-looking quality efforts are essential, but they are not sufficient on today's state of competition. They have little effect on the organization's long-term sustainability.

> If a business limits or over-emphasizes the backward-looking approach, it can expect to lose ground to its competitors. The ones who are ensuring that current products/services satisfy customers' expectations and simultaneously are constantly looking for and finding ways to offer unique solutions that separate their products/services from the pack (WATSON, 2019, p.9).

According to Watson (2019) understanding the two concepts of quality that exist in Japanese literature is particularly important because they provide the framework for the Kano Model:

a) *Atarimae Hinshitsu*: is used to describe a product/service that is 'fit for purpose/ function' and is capable of doing or performing its intended purpose. This dimension is described primarily as must-be quality in the Kano Model.
b) *Miryokuteki Hinshitsu*: refers to the 'charm of quality', and it is associated with characteristics such as appearance, sound, and touch, which customers perceive as giving 'personality' to the product/service. This dimension satisfies customers' concepts of features that are fascinating and are 'worthy of attraction' or 'fit for love'.

This understanding of quality has broadened attention beyond the currently produced offerings to include features that generate distinctive aesthetic qualities.

Kano (2001) concludes that quality has two aspects: an objective and a subjective aspect, the former being independent from the existence of man and the later has to do with what is felt, thought, or sensed. In other words, there is a subjective side of quality. Based on this lesson, Kano discusses the relation between these two aspects and proposes the Attractive Quality Theory.

Kano and his colleges Seraku, Takahashi and Tsuji published the Kano Model in 1984 on *The Journal of the Japanese Society for Quality Control* based on former insights of Kano and Takahashi. Kano *et al.* (1996) later presented this work in English.

The Kano Model has its theoretical roots in the motivator-hygiene theory from Herzberg (1966) which argues that the factors that cause job satisfaction are very different from those that cause job dissatisfaction. Whilst motivator factors, such as achievement recognition, cause job satisfaction, hygiene factors. For an example, working conditions cause job dissatisfaction when not adequately fulfilled (LILJA, 2010).

> It is a fact that we were influenced by Herzberg's Motivator-Hygiene Theory (M-H Theory) in behavioral science to develop the Attractive Quality Theory. That is, the Attractive Quality and Must-Be Quality in our theory correspond to Motivator and Hygienic factor in M-H theory (KANO, 2001, p.6).

The Kano Model explores the way in which a product attribute affects customer satisfaction. According to Löfgren and Witell (2005):

> This model displays the relationship between the physical fulfillment of a quality attribute on a product, and the perceived satisfaction of that attribute. The relationships are not equal for all quality attributes, and they also change over time (LÖFGREN; WITELL, 2005, p.6).

Customers frequently have difficulties in accurately specifying the desired product attributes, and the use of a simple questionnaire may not be able to identify customer's real needs. Therefore, methodical support is necessary to clearly identify the relevant customer requirements. One method capable of identifying the core of the customer requirements is the Kano Model (CHAUDHA *et al.*, 2010).

The Kano Model offers a useful method for classifying and comprehending customer requirements and their nature. In place of the conventional one-dimensional method, Kano's theory proposes a two-dimensional needs recognition method for quality. This provides insights on relationships, besides the physical fulfillment of requirements, which affect consumer satisfaction (CHAUDHA *et al.*, 2010).

Through the study of quality theory in philosophical, quality control, merchandising, and other literature Kano *et al.* (1996) recognized two aspects of quality – objective and subjective – and suggest that this two-dimensional perspective should replace the one-dimensional focus on objective quality. Because alone, the state of physical fulfillment, is not sufficient to explain consumer behavior.

Objective quality pertains to 'conformance to requirements' and is focused on producer's point of view, while subjective quality pertains to the 'satisfaction of users' and highlights consumer´s quality perception (KANO *et al.*, 1996). The combination of these two

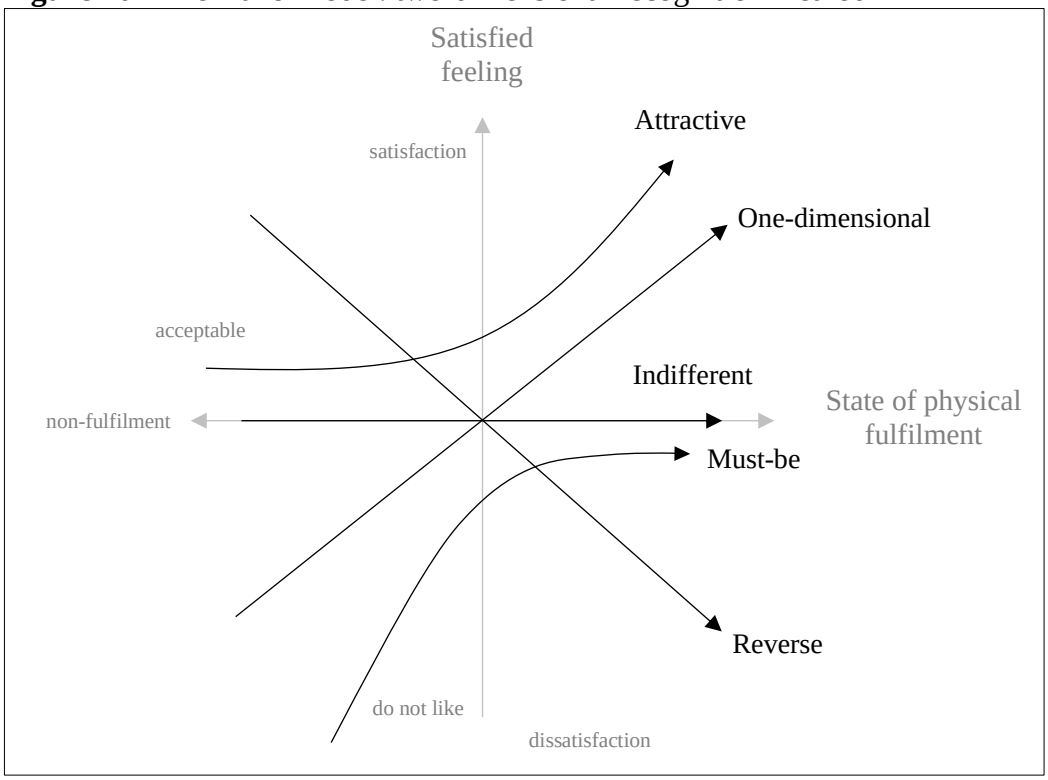
perspectives, also mentioned by Feigenbaum (1983), is recognized by Kano and his colleges who deepen the discussion on the relationship between the two viewpoints of quality by proposing the Kano Model.

It evaluates these two dimensions based on the relationship between degree of fulfillment of a quality attribute and customer satisfaction with the quality attribute. This theory has received attention of researchers and practitioners in strategic thinking, business planning, and product development to provide guidance with respect to innovation, competitiveness, and product compliance (CHAUDHA *et al.*, 2010).

The Kano Model recognizes the correlation between the two aspects of quality – physical fulfillment and user satisfaction – by categorizing quality elements in five dimensions: attractive, one-dimensional, must-be, indifferent and reverse quality elements (KANO *et al.*, 1996).

The correlation between physical fulfillment (X axis ranging from complete to non-fulfillment) and user satisfaction (Y axis ranging from satisfaction to dissatisfaction) is expressed graphically no Figure 10.

Figure 10 - The Kano Model: two-dimensional recognition method



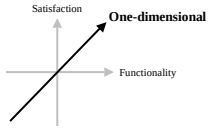
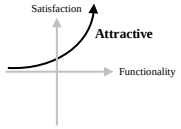
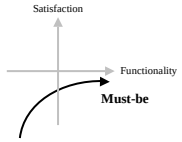
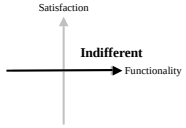
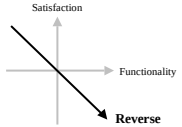
Source: adapted from Kano *et al.* (1996).

Kano *et al.* (1996) plot the five quality dimensions curves on this graph to help explain their performance. By definition Kano *et al.* (1996, p. 170) states:

a) Attractive Quality Elements (A): quality elements that when fulfilled provide satisfaction but when not fulfilled are acceptable;
b) One-dimensional Quality Elements (O): quality elements that result in satisfaction when fulfilled and in dissatisfaction when not fulfilled, the conventional way (producer's perspective) of recognizing quality;
c) Must-be Quality Elements (M): quality elements that are absolutely expected (taken for granted when fulfilled) but result in dissatisfaction when not fulfilled;
d) Indifferent Quality Elements (I): quality elements that neither result in satisfaction nor dissatisfaction, regardless of whether they are fulfilled or not;
e) Reverse Quality Elements (R): quality elements that result in dissatisfaction when fulfilled and satisfaction when not fulfilled. Sometimes users evaluate an element as 'dissatisfying' while producers have made an effort to fulfill such an element.

Each quality dimension has its design implication. One-dimension quality should focus on surpassing industry standards. A lot of effort should be invested in including at least a basic functioning level of an attractive quality attribute. Must-be attributes are industry-standard level, so they must be included in product planning and well-functioning at the costumer end. Little attention should be given for indifferent attributes, exception here for specific niches and, sometimes, indifferent attributes represent reduction opportunity. Reverse quality attributes must be avoided during product planning (MACDONALD *et al.*, 2006). Chart 4 summarizes the five quality dimensions definitions, curve performance and design implications.

Chart 4 - The Kano Model and its design implications

	Kano *et al.* (1996) definition	Explanation and Example	Curve	Curve Interpretation	Design Implications MacDonald *et al.* (2006)
One-dimensional (O)	Satisfied when fulfilled, dissatisfied when not fulfilled	Performance attributes with proportional relation between Functionality and Satisfaction[1] E.g. battery life performance, the more the better		Every increase in functionality leads to increased satisfaction	Work to increase the functionality of the attribute past industry standards
Attractive (A)	Satisfied when fulfilled, no feeling when not fulfilled	Unexpected features which, when presented, cause a positive reaction (delighters)[1] E.g. fluid touch-screen TV		A small level of functionality leads to increased satisfaction (quick rise)	Work to include attribute at a basic functioning level, as the mere presence of the feature will induce satisfaction
Must-be (M)	No feeling when fulfilled, dissatisfied when not fulfilled	Features that are expected by customers, if not present, the product will be considered incomplete or bad (basic expectations)[1] E.g. cars should have good brakes.		A small level of investment goes a long way in increasing satisfaction. But satisfaction never even reaches the positive side of the dimension (regardless of the invest in the feature)	Make sure the feature is included and functioning properly at an industry-standard level
Indifferent (I)	No feeling of satisfaction or dissatisfaction regardless of fulfillment or non-fulfillment	Features towards which costumers feel indifferent, their presence (or absence) doesn't make a real difference[1] E.g. the color of an air-conditioning vent		Straight line not affected by functionality (neutral)	Do not focus any attention here. Note that some attributes are delighting to some customers while others feel indifferent or even reverse about these attributes
Reverse (R)	Dissatisfaction when fulfilled or satisfied when not fulfilled	Cases in in which users feel opposite to the direction of efforts of producers[2] E.g. high-tech products for a basic model user		Every increase in functionality leads to dissatisfaction	Make sure not to include these attributes

Sources: Kano *et al.* (1996), [1]Zacarias (2015), [2]Robinson (2009), MacDonald *et al.* (2006).

In order to uncover customer's perceptions towards product's attributes the Kano questionnaire is used. It consists of a pair of questions for each feature:

a) One asks customers how they feel if they have the feature, called functional form. For an example: How would you feel if the packaging has printed art?
b) The other asks how they feel if they did not have the feature, named dysfunctional form. For an example: How would you feel if the packaging has no printed art (plain)?

This questionnaire made it possible to classify product and service attributes into each of the five categories of quality elements (LILJA, 2010). These close-ended questions are answered on a standard scale of: like, must-be, no feeling, acceptable or do not like.

The questions should be thoroughly structured by experts on the evaluated feature, which may include information triangulation, that is, the use of multiple methods or data sources in qualitative research to develop a comprehensive understanding of phenomena.

Once the questionnaire is set and tested, answers are collected, and the pair of answers is evaluated with the help of standard Chart 5.

Chart 5 - Two-dimensional evaluation chart

Customer Requirements		*Dysfunctional*				
		Like	Must-be	No feeling	Acceptable	Do not like
Functional	Like	Skeptical	Attractive	Attractive	Attractive	One-dimensional
	Must-be	Reverse	Indifferent	Indifferent	Indifferent	Must-be
	No feeling	Reverse	Indifferent	Indifferent	Indifferent	Must-be
	Acceptable	Reverse	Indifferent	Indifferent	Indifferent	Must-be
	Do not like	Reverse	Reverse	Reverse	Reverse	Skeptical

Source: adapted from Kano *et al.* (1996).

Using the previous example of paired question:

a) Functional question: How would you feel if the packaging has printed art?
   Answer: No feeling
b) Dysfunctional question: How would you feel if the packaging has no printed art (plain)?
   Answer: Like

In this single case of paired question, the evaluation of printed art would be accounted as reverse. If another costumer answers the same paired question as 'no feeling for printed art'

and ‘no feeling for plain packaging’ the printed art evaluation would be accounted as indifferent.

Skeptical evaluation stands for an answer that is difficult to take as a general evaluation. It remains unclear if the question was understood or not. This may be due to the difficulty of the question, poor expression of answer or poor understanding of quality element (KANO e*t al.*, 1996).

The Kano Model brings new perspectives, while trying to explain the correlation between objective quality and subjective quality as established by Shewhart (1931).

Once all paired questions have been evaluated the results can be summarized as designed in Table 5. In this example, the tendency in evaluation of the quality element ‘X’ is one-dimensional, since the 51% of the paired answers indicate this evaluation (most frequent).

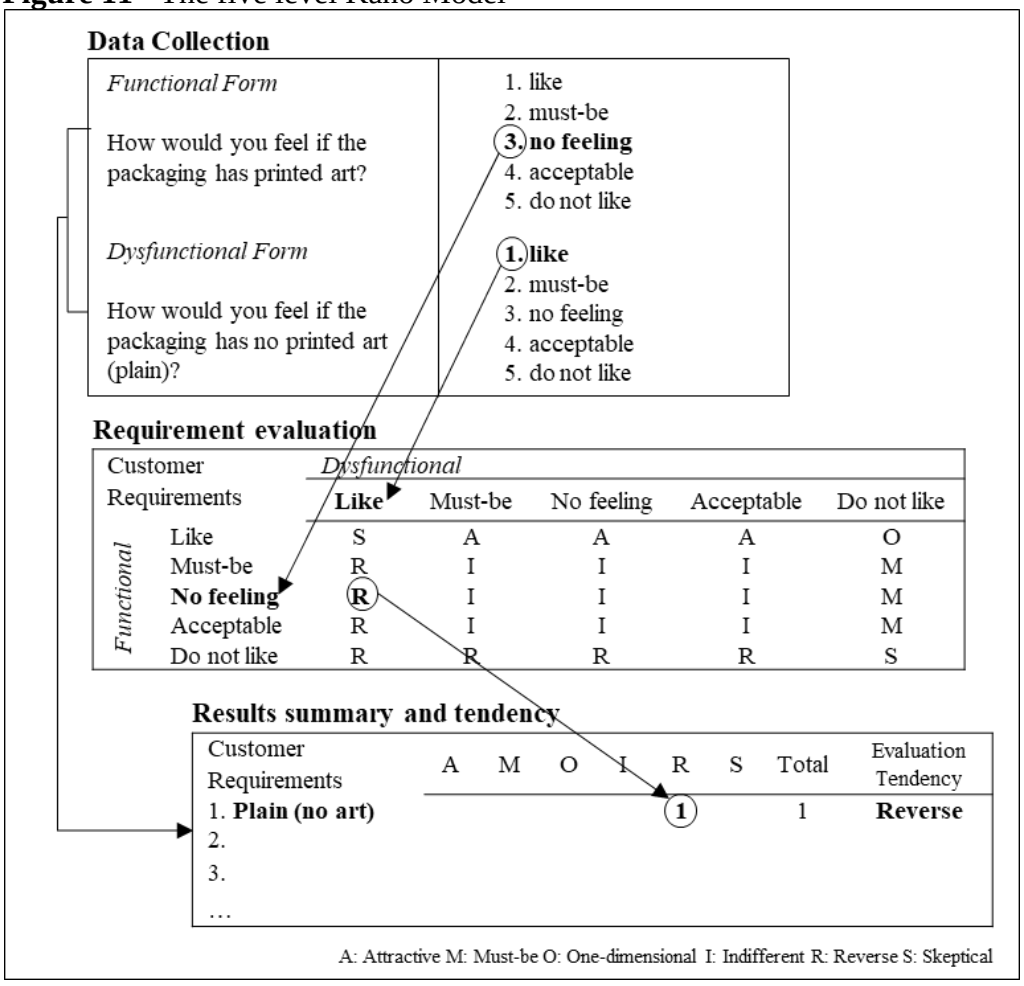
Table 5 - Trends in quality elements and summary results (hypothetical data)

Quality element	Attract.	One-dim.	Must-be	Indiff.	Reverse	Skept.	Total	Tendency in evaluation
X	55 (11%)	**255 (51%)**	175 (35%)	14 (3%)	0 (0%)	1 (5%)	500 (100%)	**One-dimensional**
Y	**227 (45%)**	86 (17%)	27 (5%)	7 (1%)	67 (13%)	62 (12%)	475 (100%)	**Attractive**
Z	12 (2%)	46 (9%)	**425 (85%)**	15 (3%)	1 (0%)	1 (0%)	500 (100%)	**Must-be**

Source: Kano *et al.* (1996). Number of paired answer evaluation, % in ( ).

The Kano Model usage by practitioners and researchers normally fulfills the following steps: (1) Choose product features and users for analysis; (2) Kano questionnaire preparation; (3) Data collection; (4) Studying the data and analyzing the results (5) Inputs for product planning. Steps 3 and 4 are detailed on Figure 11 considering the packaging art example.

Figure 11 - The five level Kano Model



Source: Author.
Attractive (A), One-dimensional (O), Must-be (M), Indifferent (I), Reverse (R), Skeptical (S).

According to Kano (2001) the Theory of Attractive Quality originated because of the lack of explanatory power of a one-dimensional recognition of quality. For instance, Löfgren and Witell (2005) state that people are satisfied if a package of milk extends the expiry date of milk and dissatisfied if the package shortens the expiry date of milk. However, for a quality attribute such as leakage, people are not satisfied if the package does not leak but are very dissatisfied if it does. The one-dimensional view of quality can explain the role of expiry dates but not leakage.

The Kano Model represents an advancement in the way new products can be planned or improved. In the past, the emphasis of product planning was on improving the physical fulfillment of each quality element using a one-dimensional quality approach. Now, with a two-dimension perspective, satisfaction improvement and dissatisfaction elimination activities are more efficient due to a more sophisticated method for understanding the relationship between quality elements and customer satisfaction. As a result, priority quality elements are selected

and clarified, product planning is more accurate and products have a better chance of success in the marketplace (KANO *et al.*, 1996).

Improving all attributes of quality will not lead to satisfied customers, as not all attributes are equal in their eyes. Some quality attributes will increase the value to customers because they are attractive and do not detract even when their physical fulfillment is not strong (WATSON, 2019).

The Theory of Attractive Quality derived from the Kano Model predicts that product attributes are dynamic. In other words, an attribute will change over time from being attractive, to one-dimensional, to must-be, to indifferent. Kano *et al.*, (2001) provide empirical evidence for the dynamics of the remote control for a television that has followed a life cycle such as the following: indifferent quality > attractive quality > one-dimensional quality > must-be quality. By investigating customer perceptions of remote controls through Kano questionnaires in 1983, 1989, and 1998, Kano (2001) shows that the remote control was an attractive attribute in 1983, a one-dimensional attribute in 1989, and by 1998 the remote control had turned into a must-be item (LÖFGREN; WITELL, 2005).

What customers feel about some product attribute now is not what they will feel in the future. Attractive features turn into one-dimensional and must-be features as time goes by. Considering Zacarias's (2015) iPhone example, the fluid touchscreen interaction that delighted costumer in 2007, became just a basic expectation by 2015. This disenchantment is due to many different factors, including technological evolution, and the emergence of competitors, all vying to bring the same functionality after the first mover. For this reason, every analysis done at a given point in time is just a photograph reflecting that moment's reality (ZACARIAS, 2015).

2.3.1 **The Kano 'Revised Models'**

The traditional Kano Model (KANO *et al.*, 1984; KANO *et. al.*, 1996) follows three steps: Kano questionnaire, Kano evaluation table, and Kano category result. The Kano questionnaire contains a set of question pairs for each product attribute. The question set includes a functional and a dysfunctional form that captures customers' responses when a product has or does not have a certain attribute respectively. The questionnaire is given to a group of customers and their answers are compared to the Kano evaluation table to understand their perceptions of a product attribute. The attribute is then categorized based on the most common responses (the most frequent evaluation) from all the survey participants. However, if

the responses are evenly distributed between multiple classifications, it becomes harder to accurately classify the attribute (VIOLANTE; VEZZETI, 2017).

The traditional Kano Model only focuses on the classification method and on the qualitative descriptions of various relationship curves. Limited quantitative analysis or measurement of the relationships is discussed in the traditional Kano model. The Kano Model's qualitative categories may not accurately reflect the level of customer satisfaction. Additionally, the Kano Model does not have a specific, measurable way to determine the level of customer satisfaction (VIOLANTE; VEZZETI, 2017).

Although Kano categories can help designers understand customer needs, alone they cannot be used as concrete criteria for decision-making. This is because they do not distinguish between attributes within the same category. Therefore, it is important for managers to understand the priorities of improving the performance of these quality attributes, especially when dealing with resource limitations (VIOLANTE; VEZZETI, 2017).

Building upon the foundations of the traditional Kano Model, various methods have been proposed to enhance the model by incorporating quantitative analysis in order to more accurately understand customer needs. These approaches aim to move beyond the use of qualitative descriptions and incorporate more objective, numerical data.

Rashid (2010) reviewed existing literature regarding Kano Model and listed 39 papers from 1993 to 2010. Including Berger *et al.* (1993) approaches, Xu *et al.* (2008) proposal and several different fuzzy approaches.

Rasmussen (2017) states it has become clear that many different researchers have further developed the Kano model for different purposes. The Kano Model can still be improved and in order to better determine how much a product features can influence customer satisfaction.

Based on the Customer Satisfaction coefficient (BERGER *et al.*, 1993), customer satisfaction and customer dissatisfaction can be determined to illustrate the relationship between customer satisfaction and customer requirement fulfillment. Another method to support the decision making was created by Xu *et al.* (2008). By using score matrix for functional/dysfunctional features and self-stated importance, a vector value pair can be calculated and plotted in a two-dimensional diagram.

The work of Violante; Vezzeti (2017) describes strengths and weaknesses of qualitative and quantitative Kano approaches such as regressions models, Berger’s Customer Satisfaction coefficients, Analytical Kano, Fuzzy, and Continuous Fuzzy.

Berger *et al.* (1993) states that it is particularly important to understand the average impact that a product requirement has on the overall satisfaction of customers. The Customer Satisfaction coefficient can indicate whether meeting this requirement will increase satisfaction or if it simply prevents the customer from being dissatisfied. This helps to understand the importance of fulfilling the requirement for the overall satisfaction of the customer base.

The Customer Satisfaction coefficient indicates the percentage of customers that expressed satisfaction with the existence of a certain feature and in case of its 'non-fulfilment', the percentage of customers that expressed dissatisfaction. Determining the level of satisfaction or dissatisfaction that a particular requirement brings to customers is crucial in order to maintain a strong competitive advantage in business. This helps to ensure that the needs and preferences of the customers are being met and that the company is able to remain competitive in the market. However, the original Kano method and the Berger's Customer Satisfaction coefficient do not identify the degree of satisfaction, but only the percentage of satisfied or dissatisfied customers (VIOLANTE; VEZZETI, 2017).

According to Violante; Vezzeti (2017), the Customer Satisfaction coefficient has the advantage of providing quantitative values for satisfaction and dissatisfaction based on non-fulfilment or fulfilment. This can help to quantify the impact of a requirement more accurately on customer satisfaction.

Based on the findings of Violante and Vezzeti (2017) a weakness of the Customer Satisfaction coefficient is that the terms 'the existence of a certain Customer Requirements (or its sufficiency) and non-fulfilment of a customer requirements', used to define the level of fulfillment of the customer requirements, can be vague and may make it challenging to incorporate its values into quantitative analysis. Furthermore, the Customer Satisfaction coefficient does not provide a measure of the level of satisfaction, but only indicates the percentage of satisfied or dissatisfied customers. It does not offer any information on the intensity of the satisfaction or dissatisfaction experienced by these customers (VIOLANTE; VEZZETI, 2017).

2.3.1.1 Customer Satisfaction coefficient

Only based on the frequency of answers, it can be difficult to determine how much a product requirement/feature can influence customer satisfaction. Berger *et al.* (1993) states it is particularly important to understand the average impact that a product requirement has on the overall satisfaction of customers. The Customer Satisfaction coefficient can indicate whether meeting this requirement will increase satisfaction or if it simply prevents the customer from being dissatisfied. The Customer Satisfaction coefficient is indicative of how strongly a product feature may influence satisfaction (Equation 1) or customer dissatisfaction (Equation 2) in case of its 'nonfulfillment'. In order to calculate the average impact on satisfaction the following equation is used. Here '*A*' stands for the frequency of Attractive quality classification, '*O*' represents the frequency of One-dimensional, '*M*' the Must-be and '*I*' the frequency of Indifferent classification.

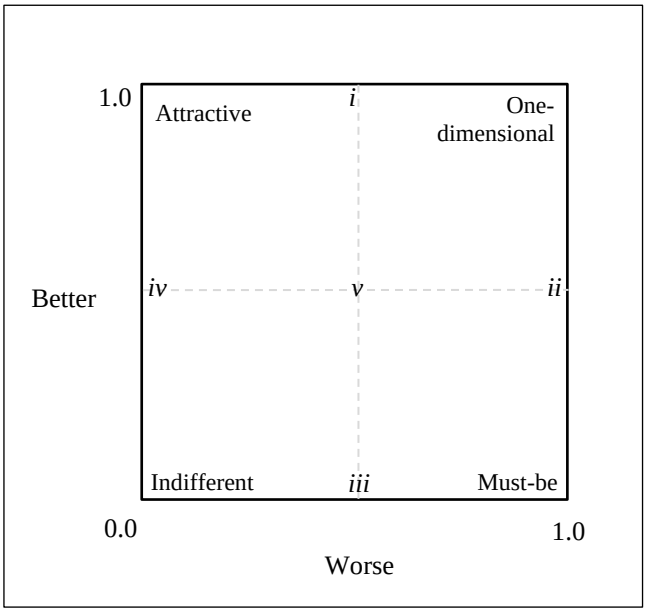
$$\text{Satisfaction index (SI) or Better} = \frac{(A+O)}{(A+O+M+I)} \quad (1)$$

$$\text{Dissatisfaction index (DI) or Worse} = -\frac{(M+O)}{(A+O+M+I)} \quad (2)$$

The positive 'Better' numbers are indicative of the situation where, on average, customer satisfaction will be increased by providing these (attractive and one-dimensional) elements. The negative 'Worse' numbers are indicative of the situation where customer satisfaction will be decreased if these (one-dimensional and must-be) elements are not included. To look at it from a slightly different angle, 'Better' indicates how much customer satisfaction is increased by our providing a feature 'Worse' indicates how much customer satisfaction is decreased by our not providing the feature (BERGER *et al.*, 1993).

Pairs of 'Better and Worse' points for each customer requirement can be plotted on a two-dimensional graph as shown on Figure 12.

Figure 12 - Two-Dimensional Representation of Kano Quality Categories



Source: adapted from BERGER *et al.* (1993).

In the graph in Figure 12, 'Better' runs from 0.0 to 1.0 up the vertical axis, and 'Worse' runs from 0.0 to 1.0 along the horizontal axis (the minus sign has been left off 'Worse' on this graph*). As an example, if there are 10 responses regarding a particular customer requirement and all of them were rated attractive, the point is plotted at the top left corner, because de XY pair is (0,1) according to Equations (3) and (4). Point *v* on Figure 11 represents the exact middle of graph with evenly split responses among Attractive, One-dimensional, Must-be, and Indifferent dimensions. Points *i, ii,iii* and *iv* and iii are characterized on Chart 6.

$$\text{X = Worse* = } \frac{(M+O)}{(A+O+M+I)} = \frac{(0+0)}{(10+0+0+0)} = 0.0 \quad (3)$$

$$\text{Y = Better = } \frac{(A+O)}{(A+O+M+I)} = \frac{(10+0)}{(10+0+0+0)} = 1.0 \quad (4)$$

Chart 6 - Description of *Points* in Figure 12.

Distribution of response	XY pair	Location on Figure 11
All Attractive	(0,1)	Top left corner
All One-dimension	(1,1)	Top right corner
All Must-be	(1,0)	Bottom right corner
All Indifferent	(0,0)	Bottom left corner
Point i - Evenly split between Attractive and One-dimension	(0.5,1)	Middle of top edge
Point ii - Evenly split between One-dimensional and Must-be	(1, -5)	Middle of right edge
Point iii – Evenly split between Must-be and Indifferent	(0.5, 0)	Middle of bottom edge
Point iv – Evenly split between Indifferent and Attractive	(0, 0.5)	Middle of left edge
Point v – Evenly split among Attractive, One-dimensional, Must-be, and Indifferent	(0.5, 0.5)	Exact middle of graph

Source: adapted from Berger *et al.* (1993).

The value of these indexes can vary between 0 and 1. The positive Customer Satisfaction coefficient ranges from 0 to 1; the closer the value is to 1, the higher the influence on customer satisfaction. A positive Customer Satisfaction coefficient which approaches 0 signifies that there is very little influence. At the same time, however, one must also take the negative Customer Satisfaction coefficient into consideration. If it approaches −1, the influence on customer dissatisfaction is especially strong if the analyzed product feature is not met (CHAUDHA, 2010).

3 RESEARCH METHOD

Researchers distinguish science from common sense through the rigorous application of the problem-solving method. The premise of objectivity, where no subjectivity or influence of the researcher interferes with research variables, refers to the positivist scientific approach. The positivist view, marked by rigor and objectivity, often uses mathematical language to justify solutions to its problems. In this quantitative approach, research variables arise from nature or are derived from a theory, being defined before the observation or experimentation is carried out. Thus, the measurement of these variables is a natural consequence that contributes to the objectivity of science, with its main concerns being measurability, causality, generalization, and replication (MARTINS, 2012).

There are two research approaches that can be used to achieve research objectives, quantitative and qualitative (AMARATUNGA *et al.*, 2002). The main distinctive characteristic between qualitative and quantitative research, is the emphasis on the perspective of the individual being studied in qualitative research (BRYMAN, 1989).

Research interested in the perspectives of individuals, as well as the interpretation of their environment, tends to a qualitative approach. In production engineering, qualitative research is materialized through visits to the researched organization, reporting of observations, and collecting evidence to identify and report the subjective reality of the individuals involved in the research (MARTINS, 2012). In contrast, the most frequent research methods used in the field of production engineering to conduct quantitative research are survey, modeling/simulation, experiment, and quasi-experiment (MARTINS, 2012).

However, the qualitative approach is not averse to quantifying variables, and sometimes there is quantification of variables in this type of research (BRYMAN, 1989). Additionally, Creswell and Clark (2006) justify the simultaneous use of qualitative and quantitative approaches due to the complementarity of the methodological concepts of scientific research. Together both approaches allow a better understanding of research problems than each of the approaches would allow individually.

According to Van Maanen (1979) qualitative and quantitative methodology are not mutually exclusive, the combination of approaches allows the advantage of one to mitigate the disadvantage of the other. For example, the quantitative approach is weak in understanding the context of the phenomenon, while the qualitative approach is not. On the other hand, the quantitative approach is less susceptible to biases in data collection than the qualitative

approach. In this way, it is possible to strengthen the approaches by combining them (MARTINS, 2012).

When one of the approaches, alone, does not answer the research question, the combination of the quantitative and qualitative approaches provides a broader and more complete view. For example, in a case study, a survey can be carried out to identify some trend of opinion among individuals (MARTINS, 2012). Chart 7 presents the characteristics of the main methods applied to Production Engineering for qualitative and quantitative research and the methods applied to this study.

The aim of this dissertation was to identify spare parts packaging features, and thereafter, determine key primary packaging attributes from the perspective of an automotive manufacturer in Brazil. To achieve this objective, a qualitative approach and the case study method were chosen. The case study involved other methods for the quantification of variables and analysis of the main spare parts attributes and features from the dealer’s representative perspective, through the application of Kano's method. Therefore, Chart 7 shows the main methods used by the research and the next section details the steps for the research.

Chart 7 - Production Engineering's main research approaches and methods

Research Characteristics	Approaches and Methods				
	Qualitative		**Quantitative**		
	Case study[1]	Action Research[2]	**Survey**[3]	Experiment and quasi-experiment[4]	Modeling and simulation[5]
Researcher's Perspective	**Investigative**	Participatory	**Investigative**	Participatory	Investigative
Strict control of search variables	No	No	Yes	Yes	Yes
Concurrency between search & action-results	No	Yes	No	Yes	No
Provides for the modification of the object of study	No	Yes	No	Yes	No
Requires the presence and active participation of the researcher in the solution	No	Yes	No	Yes	No
Allows generalization of results	No	No	**Yes**	Yes	Possibly
Incorporates new perspectives brought by the surveyed	Yes	Yes	No	No	No
Knowledge base	**Theoretical-practical**	Theoretical-practical	**Theoretical-investigative**	Theoretical	Theoretical
Key data collection methods	**Reporting observations, interviews, discussions, documents**	Triangulated information: observations, interviews, documents	**Structured questionnaires**	Intervention and data collection protocol (statistical treatment)	Documentary research and modeling (mathematics-computational)

Sources: [1] VOSS *et al.* (2002), [2] COUGHLAN; COGHLAN (2002), [3] FORZA (2002), [4] DUTRA; KINGS (2016), [5] BERTRAND; FRANSOO (2002).
Bold highlights characteristics and methods applied to this research.

3.1 RESEARCH FRAMEWORK

A case study is an examination of a past or current event using various sources of evidence, including observations, interviews, and archival material. It aims to provide a comprehensive understanding of the phenomenon by considering the context in which it occurred (LEONARD-BARTON, 1990). According to Yin (1989) there are six sources of evidence to gather information on a case study, they are:

a) Documentation: source of relevant information, however it is necessary to verify the validity of the document with other sources of evidence;
b) File records: these are documents kept, for some reason, systematically;
c) Interviews: one of the most important sources of information, it can be structured or semi-structured in order to transform the interviewed in a researcher's ‘informant’;
d) Direct observation: through the visit to the field, observations of relevant behaviors and environmental conditions, which are a source of additional information;
e) Participatory observation: the researcher ceases to be an observer passive and starts to really participate in events;
f) Physical artifacts: they can be physical or cultural and collected or observed in the field.

This case study was done qualitatively by reviewing the literature for packaging functions, classifying applicable packaging attributes with specialists (through structured questionnaire), and crosschecking information with internal documents and direct observations. Based on the understanding of the traditional Kano Model, different approaches have been proposed to extend the Kano Model from qualitative descriptions to the quantification of variables to understand customer needs in a more accurate manner. Studies have considered the quantitative analysis of customer answers (LIZARELLI *et al.*, 2021).

The research was divided into eight stages, as shown in Chart 8:

a) Review of Literature: to identify the main attributes, a structured review of literature was conducted through Web of Science and Scopus databases. Together with cross referencing and specialist recommendations they form the body of documents for the packaging attributes survey.
b) Specialists' classification: structured questionnaire was applied to employees from 15 areas to help validate and classify the main packaging attributes found in the structured literature review. The objective was to identify specialists' perception on what are the main packaging attributes considering the list generated in the literature review.
c) Spare parts packaging attributes definition: supported by the literature and by information triangulation the list of spare parts packaging attributes was defined considering body parts for automobile and motorcycles. Observation of the current packaging in the warehouse supported attribute validation as well as internal document analysis (Packaging Development Manual).
d) Kano questionnaire definition: for each attribute, a pair of functional and dysfunctional question were defined. The questionnaire was piloted with research colleges and Spare Parts Division employees for feedbacks and questionnaire improvements.
e) Kano questionnaire application (data gathering): the Kano questionnaire (survey) was electronically sent for the dealer's network representatives and all answers were stored.
f) Attribute evaluation and Data processing: the answers for each pair of question were evaluated based on Kano *et al.* (1984). Frequency-Based attributes classification method was applied, and Customer Satisfaction coefficient calculated.
g) Input for packaging design: spare parts packaging relevant attributes were determined and classified based on the Kano Model approach. Recommendation on packaging key attributes were set and reviewed by the Packaging Development Specialist.

Chart 8 - Research steps and tools

	Packaging attributes	Spare Parts Packaging Attributes	Kano questionnaire	Kano Survey	Data processing and results discussions	Input for packaging development
Tools	Structured Literature review	Specialist classification using internal survey, documents, and direct observation	Functional & dysfunctional questions Pilot questionnaire	Questionnaire sent to dealers' representatives	Attribute evaluation FB classification CS coefficient	Packaging specialist review on Kano attribute classification
Sources	Scopus and Web of Science	Internal Spare Parts Specialists, and warehouse observation	Kano *et al.* (1984)	External Specialists (dealers' representatives)	Berger *et al.* (1993) Kano *et al.* (1984)	Internal Specialist Packaging Development

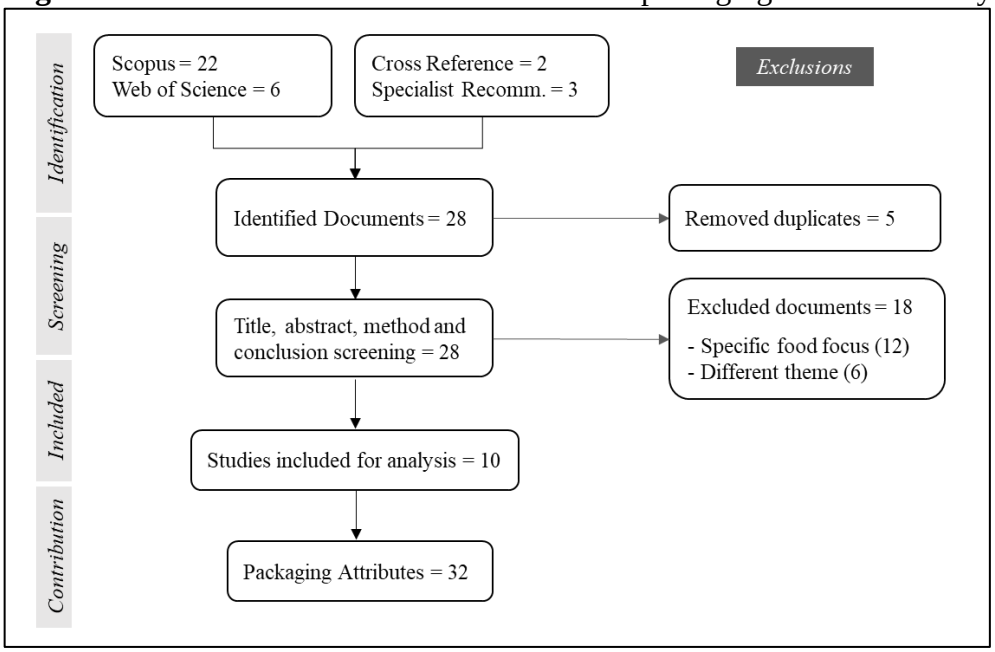
Source: Author.

3.1.1 **Structured Literature Review**

In order to gain insight into contemporary perspectives regarding packaging requirements and attributes, a structured literature review was carried out on the Scopus and Web of Science databases using the search terms 'packaging' AND ('requirement' OR 'attribute') AND ('QFD' OR 'KANO'). A filter for English peer-reviewed articles published within the past decade (2013-2023) was applied. This time frame was applied to capture modern insights on a rapidly evolving packaging function. Additional studies were included due to cross reference and specialist recommendation. These papers were the basis for identifying packaging attributes.

The search string returned 28 articles with 5 duplicates within the two databases. After screening 23 peer-reviewed articles, five of them were found to be relevant to determine quality attributes for packaging and therefore were included in this study. Exclusion criteria included specific focus such as food products, because of their intrinsic difference from spare parts, and different or distant theme, as seen on Figure 13. The complete list of the articles and the reasons for including or excluding them on this review is available at Appendix A.

Figure 13 - Articles and documents selection for packaging attributes survey



Source: Author.

Five additional studies were included due to cross reference and specialist recommendation. The studies done by Löfgren and Witell (2005) and Rundh (2005) are cited in over 170 research papers found on Web of Science. They serve as a foundation for many recent research examining packaging quality attributes and are cross references from the articles found using the above mentioned search string. Thus, both articles were included in this study, although outside the defined string time frame.

Following specialists' recommendations three additional studies help narrow packaging attributes to the automotive scope. The study conducted by Purba *et al.* (2018) is in a developing country and is focused on automotive spare parts, thus it was included in this review due to its similarity in scope with the present study. Sundestrand and Sjöström's (2022) and Lima's (2009) master theses focus on the packaging of auto parts, with the latter being conducted in Brazil. This automotive scope complements the broader approach of the articles found using the set search string and form the body of documents used by this study to survey packaging attributes.

3.1.2 **Specialists' classification**

A structured questionnaire was applied to 15 employees at the strategic and tactical levels as the primary source of internal selection for packaging attributes. The respondents had an average of 10 years of experience in the automotive sector. The objective of this stage of the method was to present the attributes selected in the literature and identify which attributes were most relevant according to the experts through a survey instrument. The chosen experts were from the following 15 areas: procurement, cost management, project planning, indirect material planning, supply chain, product development, marketing, demand planning, financial, quality management, logistic, purchasing, import and export, and transportation planning.

The questionnaire comprised of 32 statements concerning primary packaging attributes to be evaluated through a Likert scale (Chart 9) to identify the importance of each attribute. Five additional open-ended questions were included to characterize the respondent profile and to allow comments regarding whether any listed packaging was not applicable to spare parts (body parts), or new attributes should be considered, this could enrich the literature review.

Chart 9 - Packaging attribute statements surveyed in specialists' validation.

Packaging attribute	Statement
Easy to grip	Spare parts packaging should be designed with features that make it comfortable and easy to hold or grasp.
Easy to open & use	Spare parts packaging should be effortless to open and allow for convenient and user-friendly product access.
Easy to empty completely	Spare parts packaging should enable consumers to remove the entire contents without any difficulty or product waste.
Easy to dose	Spare parts packaging should facilitate accurate and controlled dispensing or portioning of the product.
User-friendly & Convenience	Spare parts packaging should prioritize consumer convenience, making it intuitive and hassle-free to use.
Reusable	Spare parts packaging should be designed to be used multiple times, reducing waste and offering extended functionality.
Easy to recycle and dispose	Spare parts packaging should be easily to discarded into waste after use, designed with materials and features that make it straightforward and convenient for consumers to recycle after use.
Facilitates handling and distribution	Spare parts packaging should be designed to streamline transportation, storage, and handling processes.
Fits in storage spaces	Spare parts packaging should be designed to fit efficiently into various storage spaces.
Right size, quantity or weight	Spare parts packaging should be appropriately sized, offering the desired quantity or weight, meeting consumer need.
Additional Functions & Innovation	Spare parts packaging should incorporate extra features or innovative elements beyond its primary function.
Protection & preservation	Spare parts packaging should safeguard the product from damage, spoilage, or deterioration during storage and transport.
Strong packaging	Spare parts packaging should be robust and resilient, providing high levels of strength and protection for the product.
Theft-prevention	Spare parts packaging should incorporate measures to deter theft or tampering of the product.
Resealability	Spare parts packaging should be designed to securely resealed after opening, preserving the product's freshness and integrity.
Stackable	Spare parts packaging should be designed to be easily stacked, optimizing space utilization during transportation and storage.
Hygienic & safety	Spare parts packaging should maintain the product's hygiene and safety, preventing contamination or adverse effects.
Leakage proof	Spare parts packaging should effectively prevent leakage or spillage of the product.
Recycled material	Spare parts packaging should be made from recycled materials reducing environmental impact and promoting sustainability.
Unique and hard to copy	Spare parts packaging should incorporate distinctive elements, making it difficult to imitate or replicate.
Customer care number	Spare parts packaging should Include a contact number or information for customer support or inquiries.
Date of manufacturing	Spare parts packaging should display the date when the product was packed and/or manufactured.
Declaration of contents	Spare parts packaging should clearly state the contents or components of the product.
Instructions	Spare parts packaging should provide clear and concise instructions on how to use or assemble the product.
Open-dating information	Spare parts packaging should include information about the recommended duration or expiration date for product use.
URL & external links	Spare parts packaging should feature website addresses or links to access additional information or resources.
Symbols	Spare parts packaging should use symbols or pictograms to convey information, warnings, or usage instructions.
Aesthetically appealing	Spare parts packaging should be visually attractive and pleasing, catching the attention of consumers.
Branding & Appearance	Spare parts packaging should effectively represent the brand identity, including logos, colors, and design elements.
Communicates Quality	Spare parts packaging should visually communicate the quality and value of the product.
Sells	Spare parts packaging should be designed to engage consumers and contribute to product sales by creating a positive impression and desire to purchase.
Low cost	Spare parts packaging should be cost-effective, considering both production and materials, while still meeting functional requirements.
	Open questions
	Any other packaging attribute you would like to add to this survey?
	Would you suggest the exclusion of any listed packaging attribute because it is not applicable to body parts (spare parts)?
	How many years of experience do you have in the automotive industry?
	Current area, department or role?
	Any additional comment or suggestion to this survey?

Source: Author.

The Parts Division specialists showed their level of agreement to each of the 32 packaging attributes statement. Participants were asked to choose their level of agreement (from strongly disagree to strongly agree) to the given statement using a Likert metric scale: ‘strongly agree (5)’, ‘agree (4)’, ‘undecided (3)’, ‘disagree (2)’, ‘strongly disagree (1)’ (JOSHI *et al.*, 2015). Closed questions using Likert scale is a widely employed method for assessing the attitudes or behavior of the participant by inquiring about the degree to which they concur or dissent with a particular statement CLAVERÍA (2021). Likert scales were developed to measure people’s attitudes (LIKERT, 1932) and helps to convert qualitative values to quantitative value for a better statistical analysis (SANTINO *et al.*, 2022). Higher the level of agreement on the statements indicates a higher perceived importance of the attribute.

To rank the packaging attributes their mean Likert value (Equation 5) was determined, whereas; *x* is a packaging attribute and *n* is the numbers of valid answers from the survey.

$$\bar{x} = \frac{\sum x}{n} \tag{5}$$

The top 10 packaging attributes ranked by the Parts Division specialists presented in section 4.3 was the focus of the Kano questionnaire applied to the network of autoparts dealer’s representatives. This quantity restriction is due to the time limit of 15 minutes inquiry set by the Spare Parts Division.

The second source of qualitative evidence involved direct observation through visits at Part Division’s warehouse, aiming to identify resonance and/or discordance to the top 10 packaging attributes. The Packaging Development Manual (PDM, 2020) was checked as source of packaging characteristics and development procedures. After that, a structured interview with the Packaging Development Specialist checked the adequacy of the packaging attributes.

3.1.3 **Kano Survey**

Once ranked the top 10 primary packaging attributes were checked to see if they were in line with the packaging guideline and in accordance with the current packaging. Then the Spare Parts Packaging Development Specialist briefly discussed the top 10 packaging attributes and there adequacy according to his experience. Thereupon the Kano questionnaire was built.

Quantitatively the dealer’s network representatives were surveyed using the Kano questionnaire, sent online, for their insights on those listed packaging attributes. Direct access to dealers was not allowed, thus dealer’s representatives were responsible for answering the

Kano Questionnaire. A dealer network representative is a group of associates responsible for managing relationships between the automotive manufacturer and the network of dealers. They act as liaison, providing support, training, and guidance to dealers, while also ensuring company policies, procedures, and standards are upheld. They are also involved in sales forecasting, market analysis, and resolving issues arising within the dealer network. They play a crucial role in maintain strong partnership between the manufacturer and its dealer, echoing the costumer's voice.

For each one of the top 10 packaging attributes a pair of functional and dysfunctional question was defined. These packaging attributes were found relevant for spare parts and cover a range of features that customers might interact with. The scale of answers to the Kano questions was in accordance with Xu *et al.* (2008) approach, as the following: 'I like it', 'I expect it', 'I am neutral', 'I can tolerate it', and 'I dislike it'.

Pilot testing involved administering the Kano questionnaire to a small group of individuals who represent the survey's target population: three Spare Parts Division employees, one dealer's representative, and an academic researcher. The purpose of pilot testing is to identify any issues with the questionnaire, such as confusing or unclear questions, problems with the response scale, or any unforeseen challenges in data collection.

After administering the pilot questionnaire, the answers were collected and analyzed, looking for patterns of confusion or any feedback from participants about the questionnaire's clarity and usability. This was done to ensure that the attributes are clear and specific, avoiding ambiguity in respondents' answers. Iterative improvements through pilot testing ensure that the final version of the Kano questionnaire is well-designed and capable of generation valuable data.

The final version of the Kano questionnaire was electronically sent to representatives of 25 dealers nationwide. The representatives used *Microsoft Forms* to access and answer the questionnaire. After 15 days and two follow-ups, 22 valid answered questionnaires were accounted for and stored, this represented an 88% answer rate. This survey had the participation of professionals with an average of 15 years of experience in the automotive sector. Once the answers were downloaded from *Microsoft Forms* each pair of answers was evaluated according to Kano's two-dimensional evaluation chart (Kano *et al.*, 1984) available at Appendix C.

The questionnaire results were analyzed according to Kano *et al.* (1984) and Berger *et al.* (1993). With the Kano results, the satisfaction and dissatisfaction index were calculated, and the packaging attributes were classified into indifferent, must-be, attractive, and one-dimensional Kano's categories.

The Customer Satisfaction coefficient proposed by Berger *et al.* (1993) complements Kano *et al.* (1984) classification by indicating whether meeting a requirement will increase satisfaction or if it simply prevents the customer from being dissatisfied. This helps to understand the importance of fulfilling the requirement for the overall satisfaction.

A structured interview with the Packaging Development Specialist enriched the attribute classification. During this interview the Kano's attributes classification was presented to the Packaging Development Specialist, and he was asked to review and express his opinion regarding the classification. Subsequently, he was asked to choose his personal attribute classification. This structed interview aimed to validate the adequacy of the primary packaging attributes classification. The Packaging Development Specialist has 10 years of experience with packaging engineering and for the last 5 years is responsible for packaging specification at the Spare Parts Division.

The result can, by providing recommendations, assist the Spare Parts Division in ensuring that their primary packaging attributes contribute to customer satisfaction. Thus, this qualitative research used the quantification of variables and case study method to identify spare parts packaging features and to determine key primary packaging attributes from the perspective of an automotive manufacturer in Brazil. The combination of these methods allows for a more comprehensive understanding of the research problem and the development of a practical solution.

4 RESULTS AND DISCUSSION

This chapter shares the study's findings, featuring the outcomes of a structured literature review. Within this process, 32 packaging attributes were pinpointed and their significance was assessed by spare parts specialists through ranking. A Kano questionnaire was applied to dealers' representatives and the classification of spare parts primary packaging attributes used both the Frequency-Based method and the Customer Satisfaction method. The Packaging Development Specialists then reviews the attribute classification and reports his insights. The last section of this chapter discusses spare parts key attributes.

4.2 PACKAGING ATTRIBUTES: A STRUCTURED LITERATURE REVIEW

A structured review of literature was conducted through two databases, cross referencing, and specialist recommendations to identify the packaging main attributes, as detailed in section 3.1.1. Ten papers were selected through the structured literature review for the identification of packaging attributes and will be presented in this section, as well as the compilation of these attributes. These papers help to unfold packaging's multiple functions into several packaging attributes and explain how they may influence consumers' perception of packaging quality.

- *Kano's Theory of Attractive Quality and Packaging in the Quality Experience by Löfgren; Witell (2005)*

According to Löfgren and Witell (2005) packaging has traditionally been seen as an important part of the physical product in the sense that it stores and protects its content. As customers become more demanding, the role of packaging becomes more important, as it can be used to provide different service dimensions (for example: convenience, information, and innovation). Packaging quality perception is created both at the point of purchase, working as a silent salesman, and during usage with instructions, convenience, hygiene, user interaction, disposal, recycling, and reuse facility. As a result, packaging quality attributes need to be designed for displaying quality both when on a shelf in a store and during usage by the end-user, bearing several handling stages, and transportation throughout the process (LÖFGREN; WITELL, 2005).

Löfgren and Witell (2005) recognize 24 quality attributes of packaging and divide them into three entities: a technical, an ergonomic, and a communicative entity:

a) Technical entity: protection, leakage, resealability, recyclable material, additional functions, attractive and nice-looking print, and hygienic;
b) Ergonomic entity: easy to grip, user-friendly, easy to open, facilitates the sorting out of household waste, easy to empty completely, easy to dose, fits in storage spaces, contain just the right quantity, and easy to throw into the household waste;
c) Communicative entity: declaration of contents, instruction, symbols, open-dating, aesthetically appealing, communicates a certain brand, and appearance similar (equal) to content.

To understand how costumers perceive packaging quality in Sweden's Löfgren and Witell (2005) data was collected through a Kano questionnaire that was mailed to randomly chosen Swedes aged 16-79 asking them about their experiences of packaging in everyday commodities. They achieved 708 answered questionnaires.

When investigating unspoken product requirements customer interviews are not sufficient. Attractive requirements, for example, are often unspoken since they are unexpected. Must-be requirements are also often unspoken because they are taken for granted as product design by customers. For this reason, Löfgren and Witell (2005) chose the Kano methodology to investigate packaging's unspoken quality attributes.

They concluded that the quality attributes in the technical entity can be viewed as creators of attractive quality, while attributes in the ergonomic entity are viewed as one-dimensional quality. If the package is hard to use or dysfunctional, the customer will consider buying a different brand next time. To the whole population, the communicative entity contributed little in creating customer satisfaction. On the other hand, these attributes are important to eliminate dissatisfaction. However, there are certain groups of people that view attributes such as brand and product family category communication as highly attractive.

In short, Löfgren and Witell (2005) point out that the change of customer expectations, as customers become more demanding, means that the packaging's role becomes greater as it can be used to provide information and new functions. This paper also supports the consumer and industry trends that suggest an increasingly important role for packaging as a strategic tool as well as a marketing vehicle (LÖFGREN; WITELL, 2005).

- *The multi-faceted dimension of packaging by Rundh (2005)*

Rundh (2005) explores how packaging can contribute to competitive advantage. Five case studies covering different packages in the supply chain are presented and analyzed. The first two products are based on corrugated board and used as transport packaging solutions with different requirements and properties on the product. The three other products are based on packaging board material and represent consumer packages mainly for the retail outlet:

a) *Case 1*: material developed for usage in industries where the packed products have a high moisture content and there will be some vaporizing through the packaging material during the transportation from the filler to the supermarket;
b) *Case 2*: heavy transport packaging functions such as motors, gear boxes or other spare parts for the car industry;
c) *Case 3*: packaging board based on virgin fiber within the area of consumer packaging such as chocolate, perfume, tobacco and for graphical applications. A growing market segment is packaging of pharmaceutical products due to an older population and increased consumption of these products;
d) *Case 4*: food products. The evolution of elaborate packaging materials and supporting technologies has made it possible to make full use of the functions food has, from providing basic nourishment to a variety enjoyment. Packaging became essential for the food product concept because it gives full protection for the content and enables efficient distribution in the supply chain to the retail outlet;
e) *Case 5*: Extrusion and laminating made it possible to combine paper and plastic with other materials such as aluminum foil. Coating of board has also been a necessity for the development of packaging material for deep frozen food products (ice-cream, deep frozen fish and vegetables, bakery products, 'warm-up in the pack' products, drinking cups, etc.). But the combination of paperboard and plastic coating (LDPE, HDPE, PP, PET) must be matched according to many different requirements and needs to give the best functional and economic results.

Highlighting *Case 2*, Rundh (2005) presents gearboxes from Saab Automobile (Swedish Aerospace and Defense Company) weighting 45 kilos in a box of corrugated material and stapled with another box on a pallet for shipment to the USA. A lot of research and development together with the customer where necessary to find a box that was stiff enough for this kind of handling. The package must be efficient during distribution and resistant against moisture, which was solved by different coatings (RUNDH, 2005).

Spare parts from Volvo's distribution center in Gothenburg in Sweden are also delivered around the world and there is a large variety of spare parts which makes each shipment unique. The only thing each shipment has in common is the sensitive goods that are packed in a cost efficient manner and big boxes that can be stapled are a necessity. The sea transport is done in ordinary containers with changes in temperature, which is a risk for an attack of moisture coupled with mechanical movements during the sea transport (RUNDH, 2005).

Volkswagen, in 2005, used export boxes for different components that could be recovered after the shipment as these boxes could fold to a single sheet even if the box consists of a triple layer of corrugated board (RUNDH, 2005).

The main implications of Rundh's (2005) paper for management that packaging should be understood and taken advantage of as a strategic weapon and marketing tool for the entire business, especially within a highly competitive food industry. Different product categories emphasize the importance that different packaging materials play for the distribution and sale of most products in our society. Moreover, how important it is to understand those costumer requirements. Even if one of the main functions of packaging is to protect the product in movement, packaging is also important both for marketing and logistic issues (RUNDH, 2005).

- *Application of the QFD method in the development of packaging in an automobile company by Lima (2009)*

Lima (2009) worked on analyzing the use of Quality Function Deployment in the development of auto parts packaging for an assembly line in Brazil. The author teamed up with professionals from the following areas: production planning and control, manufacturing, process engineering, product planning, quality, labor safety and ergonomics, packaging development and a supplier of auto parts. Together they formed the Quality Function Deployment team for this project and listed 11 assembly line packaging quality requirements:

a) Preserve product integrity: maintain the dimensional and functional characteristics of the packaged product;

b) Avoid hand injuries when handling the package: avoid injury to the operator's hands when handling the package, which can be caused by sharp edges, for example;
c) Avoid physical injuries at the end of the shift (arm, back, etc.): comply with adequate ergonomic conditions (package with the right weight, with a handle to make it easier for the operator to pick up the package, etc.);
d) Not interfering with the profitability of the auto part: reduce packaging cost;
e) Low Maintenance Cost: avoid maintenance items such as: bearing, springs, etc. This is a requirement specific to returnable packaging;
f) Foldable packaging: try to develop foldable packages to minimize transportation cost, since it takes space in the trucks;
g) Pack as many parts as possible: the packaging needs to store as many parts as possible to reduce the number of times an operator will need to replenish the assembly line;
h) Stackable packaging: the packaging be securely stackable and stable when handled by a forklift;
i) Easy and fast unloading: the packaging (and its trays) must facilitate the removal of parts (for an example, disposable packaging must come with a lid; otherwise, it will be necessary to use a cutting device);
j) Correct identification: it is important to verify/consider the location of the identification and that the identification is legible;
k) Should not accumulate water or waste: all packages, before loading, must be empty and free of any dirt, water, or any impurity.

Lima (2009) emphasizes that the item ‘returnable packaging’ quality requirement was not listed because this requirement is already prioritized when developing a new packaging, as a role for assembly line supply.

Ensuring product integrity was understood by the Quality Function Deployment team as a basic packaging function, it was the most important requirement reported by the areas. If this requirement is not considered in packaging development, internal customers will feel extremely dissatisfied (LIMA, 2009).

- *A case study on FMEA-based quality improvement of packaging designs in the TFT-LCD industry by Liu et al. (2016)*

Liu *et al.* (2016) study is centered around using quality function deployment (QFD) and failure modes and effects analysis (FMEA) methodologies to examine the design of packages for semi-finished thin film transistor-liquid crystal display modules in the photoelectricity industry. Initially, a questionnaire survey was conducted among customers to identify their desired characteristics. Then, a combination of quality function deployment and failure modes and effects analysis was used to evaluate the significance of customer requirements. Through mutual assessments and investigations by QFD and design failure mode and effects analysis (DFMEA) the key factors of a product design were determined.

Liu *et al.* (2016) list the main cause of customer complaints regarding damaged products as defective cushion designs, broken cartons and gaps between cushions.

They also identify as industrial packaging needs:

a) Light weight;
b) Small in size;
c) Easy to grasp;
d) Packaging simplicity;
e) Inexpensive;
f) Good protection;
g) Being eco-friendly.

Good protection is identified as the most important requirement. Liu *et al.* (2016) conclude that customer needs can be understood by means of QFD, and improvements and preventions can be conducted via FMEA. Customer opinions and the knowledge of development teams in the professional fields can be integrated, and the critical factors of a product design can be practically planned (Liu *et al.*, 2016).

- *Packing Improvement by using of Quality Function Deployment Method by Purba et al. (2018)*

Purba *et al.* (2018) use Quality Function Deployment to find improvements for spare parts packing at Honda in Indonesia. They conducted surveys to determine the effect of packing on customers buying a spare part. Questionnaires were submitted to buyers and sellers of spare

parts in Indonesia to help prioritize 8 customer needs by building a House of Quality and a targeting a new design.

These 8 customer's needs were listed considering literature survey, benchmarking, and voice of the customer (interviews). They are as following (PURBA *et al.*, 2018):

a) Packaging not easy to damage;
b) Packaging for more safety;
c) Unique Packaging (hard to copy);
d) Packaging dimensions (cubic meter);
e) Easy recycling;
f) Easy unboxing;
g) Ergonomic;
h) Car brand and hologram decal.

Questionnaires were submitted to buyers and sellers of spare parts outside the Honda's sole agent in Indonesia. By using 1-5 scale and brainstorm, the results in Product Development showed that the most important customer needs (with grade 5) are: packing not easy to damage, improve packing for more safety and add car brand and hologram decal.

The first point for improvement found was to guarantee the quality of the spare part. Secure packing until received by the customer seems to be part of the must-be attributes. As part of this, unique packaging facilitates recognition of an original or fake spare part. While from a seller point of view, compact design makes it easy for storage and makes it easier to unbox, thereby making it more unlikely for parts to be damaged. Clients also asked for stronger packaging material to enhance product safety. Additionally, barcodes and holograms can help hinder piracy and counterfeiting by connecting consumers to the internet to check for spare part authenticity (PURBA *et al.*, 2018).

When asked about packaging art and printing color Purba *et al.* (2018) found that both customer and seller do not care about these issues. To them, what is most important is the quality of the spare part. Another finding was the impact of difficult unpacking. The customer may use of sharp or cutting objects to open packaging and inadvertently damage the spare part (PURBA *et al.*, 2018). Thus, Purba *et al.* (2018) conclude that the packaging of a product should comply with its characteristics and handling conditions, and this is not different for automotive spare parts.

- *Identifying and classifying attributes of packaging for customer satisfaction-A Kano Model approach by Dash (2021)*

In India an empirical research was conducted by Dash (2021) applying the Kano Model. The researcher was interested in find out the perception of customers on 22 packaging quality attributes. Five hundred randomly selected respondents were asked about their experience with packing on everyday commodities through a Kano structured questionnaire. The author studies packaging from four dimension. These dimensions are functional, technical, informative and visual:

a) Functional dimension: contains attributes pertaining functional use aspects of packaging, directly relation to its intended purpose and packaging performance, such as easy to grip, easy to open, easy to empty completely, easy to throw in the waste, fits in storage spaces, user-friendly, weight and additional functions;
b) Technical dimension: these aspects are related to the technical specification, designs and engineering aspects, such as hygienic, leakage proof, protection, recyclable material and resealability;
c) Informative dimension: customer care number, date of manufacturing, declaration of contents, instruction and Uniform Resource Locator;
d) Visual dimension: contains all the attribute pertaining to communication aspects of packaging, such as aesthetically appealing, appearance, communicates quality and symbols.

As result Dash (2021) found out that functional dimension contains predominantly one-dimensional attributes, which indicates that if they are complied with, the satisfaction will increase, while if that is not the case, satisfaction will go down. Technical dimension contains predominantly the must-be category which indicates that the attribute has to be fulfilled, otherwise the customer will defect the product and go to competitor products. Informative dimension contains 5 attributes, majority of which are of must-be category which has to be fulfilled at first priority otherwise it will hamper the sales of the product. Visual dimension contains predominantly one-dimensional attributes (DASH, 2021).

According to Dash (2021), through use of the Kano Model the marketer can prioritize the attributes and try to fulfill all must-be quality attributes. Specifically: easy to open, hygienic, leakage proof, protection, date of manufacturing and declaration of contents. Additionally,

packing attributes should be competitive enough in one-dimensional category such as easy to grip, easy to empty completely and user-friendly. Lastly, that attractive category such as recyclable material and resealability should be given importance in packaging to delight the customers (DASH, 2021).

- *Consumer satisfaction with packaging materials: Kano model analysis approach by Brozović et al. (2021)*

Brozović *et al.* (2021) explore a lack of research findings related to the consumers' perception of packaging materials. This paper investigates the influence of packaging materials on consumers' perception of product quality according to the Kano model of attributes classification. The study analyzed commonly available products used by consumers in their daily lives and found on store shelves. Fourteen quality attributes of various packaging materials were evaluated using five-level Kano questionnaires.

Data collection was conducted through structured interviews with 80 participants at the The University of Zagreb Faculty of Graphic Arts in Croatia with mean age of 30.5. Investigation included the following type of packaging materials: glass, rigid plastic (high-density polyethylene), tin, and flexible composite material and three food brands packaged in different materials:

a) Instant coffee (200 g) packed in glass, tin, and flexible composite material;
b) Cocoa powder (400 g) packed in rigid plastic and flexible composite material;
c) Ground cinnamon (54 g) packed in glass and flexible composite material.

The packaging quality attribute used by Brozović *et al.* (2021) were divided in two entities:

a) Technical: protection, leaking of aroma, resealability, recyclable material, attractiveness of the label.
b) Ergonomic: easy to grip, easy to open, facilitates the sorting out of household waste, reusable when empty, easy to dose, fits in storage spaces, contains just the right quantity, easy to throw in the household waste, user-friendly.

The obtained quality attributes classification results of packaging materials investigated in this study are presented on Chart 10.

Chart 10 - Packaging material attributes quality classification

Quality attributes	Classification
Protection	Combination (One-dimensional and Must-be)
Leaking the aroma	Combination (Must-be and One-dimensional)
Resealibility	Combination (Attractive and One-dimensional)
Recyclable material	Combination (Attractive and One-dimensional)
Attractiveness of the label	Indifferent
Easy to grip	Combination (one-dimensional, Attractive and indifferent)
Easy to open	Combination (Must-be, One-dimensional and Attractive)
Facilitates the sorting out of household waste	Indifferent
Reusable when empty	Attractive
Easy to dose	Combination (One-dimensional and Attractive)
Fits in storage spaces	Attractive
Contains just the right quantity	Combination (One-dimensional and Must-be)
Easy to throw in the household waste	One-dimensional
User-friendly	Combination (One-dimensional and Attractive)

Source: Brozović *et al.* (2021).

According to the findings, tin had the highest quality attributes, followed by glass and plastic. When choosing packaging materials, consumers' perception is influenced by factors such as recyclability, functionality, convenience of use, and the product's protection. Additionally, the visual appeal and attractiveness of the packaging have a significant impact on brand selection (BROZOVIĆ *et al.*, 2021).

- *New hybrid AHP-QFD-PROMETHEE decision-making support method in the hesitant fuzzy environment: an application in packaging design selection by Lima et al. (2022)*

Lima *et al.* (2022) presents a hybrid decision-making method, which jointly uses the Analytic Hierarchy Process, the Quality Function Deployment and the Preference Ranking Method for Enrichment Evaluation, as well as the Hesitant Fuzzy Linguistic Term Sets to capture hesitation and aggregate divergent opinions from different experts on packaging design for an automotive company. First, they determined the customer requirements and weights using fuzzy hesitant Analytic Hierarchy Process. The next step was to determine the degree of relationship between the customer requirements and design requirements and the requirement weights using Hesitant Fuzzy QFD method. To prioritize alternatives, they applied the Hesitant Fuzzy Preference Ranking Method for Enrichment Evaluation.

Through a closed questionnaire, the packaging requirements were listed and scores were assigned, considering a group of specialists from the internal customers who approve the packaging in an automotive industry, being the following areas: production control, manufacturing, quality and ergonomics and safety.

The specialist group identified 8 customer requirements:

a) Not to hurt the operator's hand or back;
b) Not to accumulate water;
c) Be demountable;
d) Pack as many parts as possible;
e) Preserve the integrity of the product;
f) Be able to be stacked;
g) Easy and fast loading/unloading;
h) Correct identification.

The design requirements defined by Lima *et al.* (2022) were:

a) Decrease the number of accessories;
b) Prevent contact between parts;
c) Mechanical resistance;
d) Free of burrs, sharp edges or any similar element;
e) Ergonomic Design;
f) The machined and sensitive parts of the pieces cannot be supported on the packaging;
g) Higher number of parts per package;
h) Add holes for water evacuation;
i) Clear and readable identification.

- *Packaging in Outbound Spare Part Distribution by Sundestrand and Sjöström (2022)*

Sundestrand and Sjöström (2022) point out that companies in increasingly competitive markets have realized the importance of their logistics activities being effective and efficient. Packaging is an area that highly impacts supply chain performance. The purpose of their research was to assist Volvo Group in ensuring that their processes are favorable with regard to quality, cost, and sustainability by studying the current outbound transport packaging processes. To fulfill this aim, a qualitative study was conducted. A survey was sent out to 14 distribution centers around the world at Volvo Group, followed by interviews with seven of them.

Sundestrand and Sjöström (2022) present an in-depth analysis on how the outbound transport packaging processes differs from one distribution center to another and how various

packaging processes affect quality, cost, and sustainability requirements. From a consumer perspective, some insights are brought to light:

a) Some distribution centers brand their transport packaging and others using brand-neutral packaging. For example, Curitiba's Distribution Center in Brazil brand all their packaging. On the other hand Buenos Aires in Argentina, does not. At Curitiba's Distribution Center a respondent stated: 'Our standard is to brand all boxes with the Volvo logo and Volvo label. We have this standard to keep the Volvo brand strong and because the South American customers are very sensitive about branding'.
b) Volvo's Curitiba Distribution Center follows a standardized outbound packaging process. Wooden pallets and corrugated boxes are used as transport packaging material. The purchased one-way packaging is not bought with reusability in mind. In general, in Volvo Group, one-way packaging is used when products need to be sent long distances, or when the possibility of getting the packaging back is limited. This is the case in distribution centers located in geographically large countries.

- *Environmentally sustainable plastic food packaging: A holistic life cycle thinking approach for design decisions by Jagoda et al. (2023)*

Jagoda *et al.* (2023) developed a framework combining life cycle thinking with functional analysis for systematically and holistically comparing sustainable packaging design options, considering environmental, economic, and consumer preference dimensions. The proposed approach was applied to a rigid plastic packaging case study involving ketchup bottles. Kano's theory and Quality Function Deployment were used to identify the user requirements, applicable design features, and prioritization.

The packaging functional attributes were defined through literature review and brainstorming sessions. They are divided in three categories protection, facilitate handling and communication and classified according to Kano Model as described on Chart 11.

Chart 11 - Packaging material attributes quality classification

Categories	Function Attribute	Classification
Protection	Preserving food	Must-be attributes
	Tamper proofing	Must-be attributes
	Hygienic and safety	Must-be attributes
Facilitate Handling	Ability to transport	Must-be attributes
	Ability to hold the content	Must-be attributes
	Ability to stack	Must-be attributes
	Ability to open/close	One-dimensional
	Ability to open the seal	One-dimensional
	Ability to take out food	One-dimensional
	Ability to hold	One-dimensional
	Ability to store in shelf/refrigerator	One-dimensional
Communication	Marketing	Other
	Usage instructions	Other
	Informational value	Other
	Nutritional value	Other
	Preservation methods	Other

Source: adapted from Jagoda *et al.* (2023).

The packaging features that could satisfy functional requirements were identified through a literature review. Semi-structured interviews were conducted with industrial experts to establish and validate the identified interrelationships between the functional attributes and features. The next step was to identify the features that need to be focused on during the design phase for improving consumer satisfaction (JAGODA *et al.*, 2023).

After prioritizing the features and identifying functional requirements, packaging designs were developed considering the industrial experts' perspective and the facts identified through the literature review. Must-be attributes such as food preservation, leakage and pilfer proofing were considered at the design phase. New designs for the components were inspired by the existing products while ensuring manufacturability with the existing facilities. Three different cap designs and four designs for bottle bodies were developed resulting in 12 packaging options (JAGODA *et al.*, 2023).

The environmental impacts of each design were calculated under the 18 categories. Jagoda *et al.* (2023) found a disparity between the options with the highest functional satisfaction and the lowest environmental impacts respectively. The aggregated score indicates that an option currently available in the market has the highest performance, and yet there are other options with better environmental performance.

The analysis reveals the possibility of minimizing the environmental impact of transportation by reducing the occupied volume of the packaging. The overall results show a strong correlation between the amount of material used versus environmental impact (JAGODA *et al.* 2023).

4.2.1 **Packaging attributes definition**

Reviewing these ten research (Chart 12) has contributed to understanding different customer perspectives on packaging quality. This was useful when choosing packaging attributes for this study, although, differences in projects' scope and approaches were found. The main findings and implications for this study are:

a) 24 quality attributes of packaging and divided into three entities; a technical entity, an ergonomic entity, and a communicative entity (LÖFGREN; WITELL, 2005);
b) Heavy transport packaging functions for motors, gearboxes or other spare parts for the car industry. In this case, the package must protect the product, facilitate handling, and prevent product theft (RUNDH, 2005);
c) 11 assembly line packaging quality requirements brought by Lima (2009);
d) 6 industrial packaging customer needs by Liu *et al.* (2016);
e) 8 spare parts packaging customer needs from Purba *et al.* (2018);
f) 22 quality attributes of packaging divided in for dimensions: functional, technical, informative and visual dimension (DASH, 2021);
g) 14 Packaging Quality Attributes and their kano classification by Brozović *et al.* (2021);
h) 8 assembly line packaging attributes and 9 design requirements by Lima *et al.* (2022);
i) One-way packaging discussion and branded packaging (or not) for outbound spare parts packaging (SUNDESTRAND; SJÖSTRÖM, 2022);
j) 16 packaging attributes by Jagoda *et al.* (2023) with an environmental approach.

Chart 12 - Research on customer perspectives on packaging quality

Title and Authors	Purpose	Scope	Findings & implications for this paper	Main research difference from this paper
LÖFGREN, M. WITELL L. Kano's Theory of Attractive Quality and Packaging in the Quality Experience. **Quality Management Journal**. Sweden, 2005.	An empirical investigation of how customers experience packaging in everyday commodities is conducted to increase knowledge of the role of packages in the perception of quality. The research study is based on Kano's Theory of Attractive Quality	Everyday commodities consumers aged 16-79 in Sweden. Achieved 708 answered questionnaires	**24 quality attributes of packaging** - Divided package into three entities; a technical entity, an ergonomic entity, and a communicative entity - Quality attributes in the technical entity can be viewed as creators of attractive quality - The ergonomic entity are viewed as one-dimensional quality. If the package of the product is not easy to use or functional, the customer will consider buying a different brand next time - The communicative entity contributes little in creating customer satisfaction. These attributes are important to eliminating dissatisfaction	Sweden everyday commodities focus
RUNDH, B. The multi-faceted dimension of packaging: Marketing logistic or marketing tool? **British food journal**, 2005.	The purpose of this paper is to study how packaging can contribute to competitive advantage. Aspects of the packing industry and market are reviewed	Five case studies covering different packages in the supply chain are analyzed	Different product categories emphasize the importance that different packaging materials plays for the distribution and sales of most products in our society - One case study discusses heavy transport packaging functions such as motors, gearboxes or other spare parts for the car industry. **In this case, package must protect products, facilitate handling and prevent theft**	Literature review approach with a large product spectrum
LIMA, B, P. de. **Aplicação do método QFD no desenvolvimento de embalagens em uma empresa automobilística.** Dissertação (Mestrado em Engenharia Mecânica) – Departamento de Engenharia Mecânica da Universidade de Taubaté, Taubaté-SP, 2009.	The objective of this study is to analyze the QFD method in the development of packaging for a car assembly line in Brazil. Kano must-be dimension is discussed	Auto-parts packing in a Brazilian based car factory	**11 assembly line packaging quality requirements** - The quality requirement 'to preserve the integrity of the product' is classified as a must-be requirement because when incorporated it promotes no feeling and its absence causes dissatisfaction	Assembly line packaging requirements are different from spare parts
LIU, S. F. *et al.* A case study on FMEA-based quality improvement of packaging designs in the TFT-LCD industry. **Total Quality Management & Business Excellence**, v. 27, n. 3-4, p. 413-431, 2016.	Uses QFD and failure modes and effects analysis methodologies to examine the design of packages for semi-finished thin film transistor-liquid crystal display modules in the photoelectricity industry	Semi-finished thin film transistor-liquid crystal display modules	**6 packaging customer needs:** - Light weight, small size, easy to grasp, packaging simplicity, inexpensive, good protection, and being eco-friendly	Industrial packaging focus

(cont.) **Chart 12 -** Research on customer perspectives on packaging quality

Title and Authors	Purpose	Scope	Findings & implications for this paper	Main research difference from this paper
PURBA, H. H. *et al*. Packing Improvement by using of Quality Function Deployment Method: A Case Study in Spare Part Automotive Industry in Indonesia. **International Journal of Advanced Engineering**, Management and Science, v. 4, n. 1, p. 239960. Indonesia, 2018.	QFD is used to find improvements for spare parts packing. Surveys to determine the effect of packing on customer choice or purchase of a spare part	Buyers and sellers of spare parts in Indonesia	**8 Customer needs** - Packaging not easy to damage - Packaging for more safety - Unique Packaging (hard to copy) - Packaging dimensions (cubic meter) - Easy recycling - Easy unboxing - Ergonomic - Car brand and hologram decal	Quality Function Deployment approach for spare parts packaging in Indonesia with buyers and sellers outside the sole agent
DASH, S. K. Identifying and classifying attributes of packaging for customer satisfaction-A Kano Model approach. **International Journal of Production Management and Engineering**, v. 9, n. 1, p. 57-64, 2021.	The researcher is interested in finding out the perception of the customers on 22 quality attributes of packaging using Kano Model approach	500 buyers of everyday commodities in India	**22 quality attributes of packaging** - Prioritize the attributes and try to fulfil all must be quality attributes specifically Easy to Open, Hygienic, Leakage Proof, Protection, Date of Manufacturing and Declaration of Contents - Packing attributes should be competitive enough in one dimensional category such as Easy to Grip, Easy to Empty Completely and User- Friendly - Attractive Category like recyclable material and resealability should be given importance in packaging to delight the customers	Indian everyday commodities focus
BROZOVIĆ, M. *et al*. Consumer satisfaction with packaging materials: Kano model analysis approach. **Tehnički vjesnik**, v. 28, n. 4, p. 1203-1210, 2021.	Investigates the influence of packaging materials on consumers' perception of product quality using Kano model of attributes classification	Daily life products found on Croatian store shelves	**14 Packaging Quality Attributes and their kano classification** - Tin had the highest quality attributes, followed by glass and plastic. When choosing packaging materials, consumers' perception is influenced by factors such as recyclability, functionality, convenience of use, and the product's protection	Croatian everyday commodities focus and materials other than paper packaging
LIMA, B. P. de.; DA SILVA, A. F.; MARINS, F. A. S. New hybrid AHP-QFD-PROMETHEE decision-making support method in the hesitant fuzzy environment: an application in packaging design selection. **Journal of Intelligent & Fuzzy Systems**, v. 42, n. 4, p. 2881-2897, 2022.	Decision-making support method for packaging design. Uses the Analytic Hierarchy Process, the QFD, the Preference Ranking Method for Enrichment Evaluation, as well as the Hesitant Fuzzy Linguistic Term Sets	Packaging design for an automotive company assembly line	**8 packaging attributes and 9 design requirements,** such as: - Decrease the number of accessories, prevent contact between parts, mechanical resistance, free of sharp edges ergonomic design, sensitive parts positioning, higher number of parts per package, water evacuation, and clear and readable identification	Assembly line packaging requirements are different from spare parts

(cont.) **Chart 12 -** Research on customer perspectives on packaging quality

Title and Authors	Purpose	Scope	Findings & implications for this paper	Main research difference from this paper
SUNDESTRAND, L.; SJÖSTRÖM, M. **Packaging in Outbound Spare Part Distribution.** A Study at Volvo Group. Master's Thesis in Supply Chain Management – Department of Technology management and economics, Chalmers University of Technology, Sweden, 2022.	The purpose is to, by studying the current outbound transport packaging processes, assist Volvo Group on their processes with regard to quality, cost, and sustainability. 14 distribution centers (DC) were surveyed, followed by interviews with seven of them	14 distribution centers around the world at Volvo Group	**Some distribution centers brand their transport packaging and others using brand-neutral** packaging. - DC Curitiba follows a standardized outbound packaging process. For transport packaging material, wooden pallets and corrugated boxes are used. The purchased one-way packaging is not bought with reusability in mind - **One-way packaging is used when products need to be sent long distances**, or when the possibility of getting the packaging back is limited	Outbound spare parts packaging process focus on the Volvo Group, searching for differences in distribution centers and benchmarks
JAGODA, S. U. M.; GAMAGE, J. R.; KARUNATHILAKE, H. P. Environmentally sustainable plastic food packaging: A holistic life cycle thinking approach for design decisions. **Journal of Cleaner Production**, v. 400, p. 136680, 2023.	Develop a generalizable framework combining life cycle thinking with functional analysis for systematically comparing sustainable packaging design options. Kano's theory and QFD were used to identify the user requirements. Then conjoint analysis, life cycle analysis (LCA), and analytical cost estimation was used	Ketchup bottles	**16 packaging attributes** - After prioritizing the features and identifying functional requirements, packaging designs were developed considering the industrial experts' perspectives and the facts identified through the literature review	Environmental impact focused on a food packaging

Source: Author.

The reviewed documents include 32 distinct characteristics of packaging attributes, which are outlined in Chart 13 and explained in Chart 14. Among these papers, three packaging attributes consistently emerge as recurring themes:

a) Right size, quantity or weight: appropriately sized packaging, offering the desired quantity or weight, meeting consumer need;
b) Protection & preservation: safeguards the product from damage, spoilage, or deterioration during storage and transport;
c) Hygienic & safety: maintains the product's hygiene and safety, preventing contamination or adverse effects.

The packaging attributes were categorized into four dimensions or entities, similar to the approach outlined by Dash (2021): functional, technical, informative, and visual. Each packaging attribute (Chart 13) resembles to a packaging core function, giving shape and features to the expected functions of a packaging.

The listed packaging attributes serve as a basis for the specialists' classification, through direct observations, structured questionnaire applied to Part Division's specialists, and internal documents analysis. The perspectives brought by the data collection methods (direct observations, internal survey, and document analysis) forms the packaging attributes that surveyed by the Kano Model.

Chart 13 - Packaging attributes from the reviewed literature

	Functions	Packaging attributes	LÖFGREN; W. (2005)	RUNDH (2005)	DASH (2021)	PURBA (2018)	S.; SJÖSTRÖM (2022)	LIMA (2009)	LIU *et al.* (2016)	LIMA *et al.* (2022)	BROZOVIC, *et al.* (2021)	JAGODA *et al.* (2023)
Functional	Convenience	Easy to grip	x		x	x		x		x	x	x
	Convenience	Easy to open & use	x		x	x		x		x	x	x
	Convenience	Easy to empty completely	x		x					x		
	Convenience	Easy to dose	x	x							x	x
	Convenience	User-friendly & Convenience	x	x	x				x		x	x
	Convenience	Reusable	x	x	x			x		x	x	
	Sustainability	Easy to recycle and dispose	x		x		x		x		x	
	Distribution & PE	Facilitates handling and distribution		x		x	x	x	x	x		x
	Distribution & PE	Fits in storage spaces	x		x			x	x	x	x	x
	Containment	**Right size, quantity or weight**	x	x	x	x	x	x	x	x	x	x
	Innovation	Additional Functions & Innovation	x	x	x							
Technical	Protection & Preservation	**Protection & preservation**	x	x	x	x	x	x	x	x	x	x
	Protection	Strong packaging				x	x	x		x		
	Protection	Theft-prevention		x								
	Preservation	Resealability	x		x						x	
	Distribution & PE	Stackable					x	x		x		x
	Hygienic & safety	**Hygienic & safety**	x	x	x	x	x	x	x	x	x	x
	Containment	Leakage proof	x		x						x	x
	Sustainability	Recycled material	x		x	x	x		x		x	
	Promotion	Unique and hard to copy				x						
Informative	Informs	Customer care number			x							
	Informs	Date of manufacturing			x							
	Informs	Declaration of contents	x	x	x			x		x		x
	Informs	Instructions	x	x	x					x		x
	Informs	Open-dating information	x									
	Informs	URL & external links			x							
	Informs	Symbols	x		x							

(cont.) **Chart 13 -** Packaging attributes from the reviewed literature

	Functions	Packaging attributes	LÖFGREN; W. (2005)	RUNDH (2005)	DASH (2021)	PURBA (2018)	S.; SJÖSTRÖM (2022)	LIMA (2009)	LIU *et al.* (2016)	LIMA *et al.* (2022)	BROZOVIC, *et al.* (2021)	JAGODA *et al.* (2023)
Visual	Promotion	Aesthetically appealing	x	x	x						x	x
	Promotion	Branding & Appearance	x	x	x	x	x					
	Sells	Communicates Quality	x		x							
	Sells	Sells	x	x								x
	Sells	Low cost					x	x	x			

Source: Author.

Chart 14 - Packaging attributes descriptions and explanations

Packaging attributes	Attribute description
Easy to grip	Designed with features that make it comfortable and easy to hold or grasp
Easy to open & use	Effortless to open and allows for convenient and user-friendly product access
Easy to empty completely	Enables consumers to remove the entire contents without any difficulty or product waste
Easy to dose	Facilitates accurate and controlled dispensing or portioning of the product
User-friendly & Convenience	Prioritizes consumer convenience, making it intuitive and hassle-free to use
Reusable	Can be used multiple times, reducing waste and offering extended functionality
Easy to recycle and dispose	Easily discarded into waste after use, designed with materials and features that make it straightforward and convenient for consumers to recycle after use
Facilitates handling and distribution	Designed to streamline transportation, storage, and handling processes
Fits in storage spaces	Designed to fit efficiently into various storage spaces, such as cabinets or shelves
Right size, quantity or weight	**Appropriately sized, offering the desired quantity or weight, meeting consumer need**
Additional Functions & Innovation	Incorporates extra features or innovative elements beyond its primary function
Protection & preservation	**Safeguards the product from damage, spoilage, or deterioration during storage and transport**
Strong packaging	Robust and resilient, providing high levels of strength and protection for the product
Theft-prevention	Incorporates measures to deter theft or tampering of the product
Resealability	Securely resealed after opening, preserving the product's freshness and integrity
Stackable	Designed to be easily stacked, optimizing space utilization during transportation and storage
Hygienic & safety	**Maintains the product's hygiene and safety, preventing contamination or adverse effects**
Leakage proof	Effectively prevents leakage or spillage of the product
Recycled material use	Made from recycled materials reducing environmental impact and promoting sustainability
Unique and hard to copy	Incorporates distinctive elements, making it difficult to imitate or replicate
Customer care number	Includes a contact number or information for customer support or inquiries
Date of manufacturing	Displays the date when the product was manufactured
Declaration of contents	Clearly states the contents or ingredients of the product
Instructions	Provides clear and concise instructions on how to use or assemble the product
Open-dating information	Includes information about the recommended duration or expiration date for product use
URL & external links	Features website addresses or links to access additional information or resources
Symbols	Uses symbols or pictograms to convey information, warnings, or usage instructions
Aesthetically appealing	Visually attractive and pleasing, catching the attention of consumers
Branding & Appearance	Effectively represents the brand identity, including logos, colors, and design elements
Communicates Quality	Visually communicates the quality and value of the product
Sells	Engages consumers and contributes to sales by creating a positive impression and desire to purchase
Low cost	Cost-effective, considering both production and materials, while still meeting functional requirements

Source: Author.

4.3 SPARE PART PACKAGING ATTRIBUTES: A SPECIALISTS' CLASSIFICATION

The main method employed for the specialists' classification involved applying a structured questionnaire among employees at strategic and tactical levels. This structured questionnaire contained both closed questions to classify packaging attributes from the literature and open questions to enrich the literature review.

Parts Division specialists from 15 areas showed their level of agreement (from strongly disagree to strongly agree) to those 32 packaging attributes available at Appendix B. Table 6 ranks the packaging attributes according to their mean Likert value.

Table 6 - Attributes evaluated by spare parts specialists

	Packaging attributes	Mean Likert	Packaging function
1	**Protection & preservation**	4,87	Protection & preservation
2	**Recycled material use**	4,73	Sustainability
3	**Facilitates handling and distribution**	4,67	Distribution & process efficiency
4	**Stackable**	4,60	Distribution & process efficiency
5	**Easy to recycle and dispose**	4,53	Sustainability
6	**Leakage proof**	4,53	Containment
7	**Theft-prevention**	4,40	Protection
8	**Low cost**	4,33	Sells
9	**Fits in storage spaces**	4,27	Distribution & process efficiency
10	**Hygienic & safety**	4,27	Hygienic & safety
11	Easy to grip	4,20	Convenience
12	Easy to dose	4,20	Convenience
13	Right size, quantity or weight	4,20	Containment
14	Strong packaging	4,20	Protection
15	Reusable	4,13	Containment
16	Symbols	4,13	Informs
17	Easy to empty completely	4,07	Convenience
18	Branding & Appearance	4,07	Promotion
19	Easy to open & use	4,00	Convenience
20	Customer care number	4,00	Informs
21	User-friendly & Convenience	3,93	Convenience
22	Communicates Quality	3,87	Sells
23	Date of manufacturing	3,80	Informs
24	Open-dating information	3,60	Informs
25	Resealability	3,47	Preservation
26	Additional Functions & Innovation	3,40	Innovation
27	Unique and hard to copy	3,40	Promotion
28	Declaration of contents	3,40	Informs
29	Sells	3,40	Sells
30	URL & external links	3,33	Informs
31	Aesthetically appealing	3,13	Promotion
32	Instructions	2,80	Informs

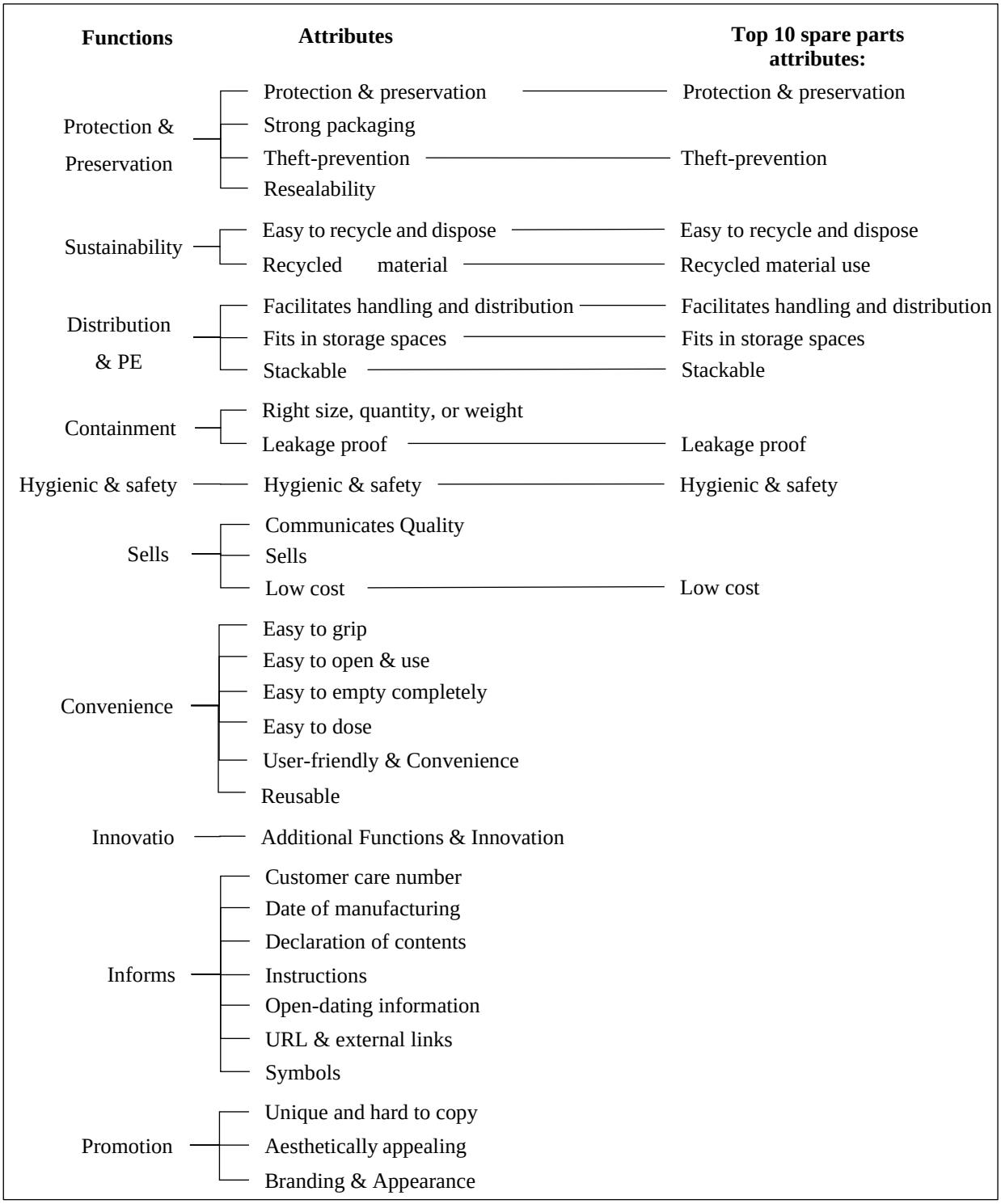
Source: Author.

No new packaging attribute was suggested by the Parts Division specialists, reassuring the literature review appropriateness. The top 10 primary packaging attributes ranked by the Parts Division specialists were:

a) Protection & preservation;
b) Recycled material use;
c) Facilitates handling and distribution;
d) Stackable;
e) Easy to recycle and dispose;
f) Leakage proof;
g) Theft-prevention;
h) Low cost;
i) Fits in storage spaces;
j) Hygienic & safety.

This demonstrates an understanding of fundamental packaging aspects like safeguarding the product and optimizing distribution and efficiency. It also emphasizes the importance of sustainability attributes, as shown in Figure 14. The convenience features were assessed with moderate agreement, while attributes linked to the selling, promotion and to inform functions figure at the lower end, showing low engagement.

Figure 14 - Packaging functions and spare parts packaging attributes classified by specialists



Source: Author.

The 10 listed primary packaging attributes served as a basis for information triangulation, through internal document analysis, direct observation, and interview with the Packaging Specialist.

Spare Parts Division's Packaging Development Manual (PDM, 2020) was analyzed specifically for instructions related to the top 10 packaging attributes.

The high level of agreement to the protection attributes such as 'Protection & preservation' and 'Theft-prevention' seem to be aligned with the PDM (2020):

> We set packaging specification to maintain quality assurance which will prevent any damages of parts for each packaging unit during the physical distribution (…) Thus drop-test and cargo-test are performed to simulate packing stress during storage and delivery (…) Packaging's priority is to protect parts quality, considering its functions, characteristics, materials, and surface treatment to select the inner packaging. The primary objective of this processes is to deliver valuable spare parts to customers in their complete condition.

The attributes of 'facilitating handling and distribution', 'Stackability', and 'Fitting in storage spaces' are linked to distribution and efficiency functions outlined in the packaging guideline:

> Logistics properties must be taken into account: check for logistics conditions and storage period, types of cargo work, transportation and handling conditions, storage in warehouse, transportation distance. Priority should be given to easier cargo handling during storage and transportation to choose the packaging.

Regarding the attributes of 'Recycled materials use' and 'Ease of recycling', the packaging manual emphasizes:

> Consider packaging's environmental impacts, prioritizing the efficient use of renewable materials and its recyclability, always in accordance with the local environmental policy.

The packaging guideline reinforces the attribute of being 'Leak-proof':

> Do not to allow protruding parts damage other parts or even the packaging. Secure parts do not move in the container.

The packaging guideline also addresses the 'Hygienic and safety attributes', ensuring the product's hygiene and safety by preventing contamination or adverse effects:

> Packaging should maintain product's properties preventing it to rust, crack, suffer discoloration, deform, suffer corrosion or deterioration (by light, heat, air and time) as well as to protect it from dust (…) A damaged package greatly increases the likelihood of a damaged part.

The packaging guideline does not explicitly state packaging should be ‘Low cost’, but the implicit focus is on efficient utilization of packaging materials.

The surveyed specialists expressed low agreement regarding the importance of ‘Aesthetically appealing’ packaging attributes, creating a positive impression, fostering consumer desire to purchase, and providing information.

This was also confirmed by direct observation of the warehouse process, specifically, the current packaging art and its printed elements. All packaging follows the same brand guideline, using a standard logo and a basic two-colored layout, this includes: box identification, volume indication (m^3), label location, recycling symbol and some packaging usage instructions (fragility, stackability, this side up, keep dry). It seems packaging is not understood as a strong promotion channel, on the other hand, it should enhance the brand image consistency.

The frequent use of double-wall corrugated board, cushioning, and kraft paper observed at the warehouse reinforces the focus on ‘protection and preservation’. Cushioning and packaging are mainly from corrugated board and monomaterial, this encourages and facilitates ‘packaging recyclability’.

A structured interview with the Packaging Development Specialist validated the adequacy of the packaging attributes, his comments on the top ten attributes are summaries in Chart 15. The spare parts packaging attributes were then considered validated by the specialists and ready for the Kano questionnaire elaboration.

Chart 15 - Comments on spare part top ten packaging attributes by the Packaging Specialist

Spare Part Packaging Attribute	Packaging Development Specialist overview and comments
Protection & preservation	I see part protection as the packaging core function. If the packaging fails to preserve parts quality other packaging attributes become minor details.
Recycled material use	Although the use of recycled content is always considered during packaging development I was (personally) surprised to see this topic with such great relevance.
Facilitates handling and distribution	Spare parts packaging must facilitate handling and distribution as it is crucial for lean logistics. After part protection, I consider handling and distribution the second most important packaging attribute.
Stackable	We suffer from lack of space in the Warehouse during picking and final distribution. Therefore, our packaging should be stackable when possible.
Easy to recycle and dispose	Environmental awareness and waste consciousness are vivid concerns not only at the Warehouse but also among the dealer network. We audit our dealers regarding environmental management in the workshops.
Leakage proof	Packaging can prevent the presence of rust, dust, and oil stains on our parts. Our packaging should not allow parts to be lost/leaked during storage and transportation.
Theft-prevention	Packaging correct closure and the use of double-walled full flaps may help prevent theft during distribution. Anti-counterfeit initiatives tend to hinder piracy and allows for product originality checks.
Low cost	Packaging cost is thoroughly managed but is not cut down over (in detriment of) parts protection.
Fits in storage spaces	Packaging should easily fit in our storage space and be safely picked.
Hygienic & safety	The parts must be clean and ready for installation and packaging helps with that. Ergonomic standards also apply to packaging.

Source: Author.

4.4 KANO QUESTIONNAIRE

For each one of the top 10 primary packaging attributes a pair of functional and dysfunctional question were defined. These packaging attributes were found to be relevant for spare parts and covers a range of features that customers might interact with. Iterative improvements through pilot testing ensured that the final version of the Kano questionnaire (Chart 16) was well-designed and capable of generating valuable data.

Based on the response given by the 22 respondents, the classification of attributes was done using the following methods: Frequency-Based classification method (FB-classification) from Kano *et al.* (1984); and Customer Satisfaction coefficient method (CS-coefficient) from Berger *et al.* (1993). The Kano Questionary results were presented and discussed with the Packaging Development Specialist.

Chart 16 - Final Kano questionnaire

Packaging Attribute	Questionnaire	Like: I like it	Must be: I expect it	No felling: I am neutral	Acceptable: I can tolerate and live with it	Do not like: I dislike it
Protection & preservation	How would you feel if the packaging provides excellent protection and preserves parts quality? How would you feel if the packaging does not protect the part adequately and compromises its quality?					
Recycled material use	How would you feel if the packaging is made of recycled materials, contributing to sustainability? How would you feel if the packaging is not made of recycled materials and does not contribute to sustainability?					
Facilitates handling and distribution	How would you feel the packaging facilitates easy handling and distribution of the parts? How would you feel if the packaging hinders the handling and distribution of the parts?					
Stackable	How would you feel if the packaging is designed to be stackable, allowing for efficient storage? How would you feel if the packaging cannot be stacked, leading to an inefficient storage?					
Easy to recycle and dispose	How would you feel if the packaging is easy to dispose of and recycle? How would you feel if the packaging is difficult to dispose of and recycle?					
Leakage proof	How would you feel if the packaging is leak-proof, preventing product loss? How would you feel if the packaging is prone to leaks or product loss?					
Theft-prevention	How would you feel if the packaging includes anti-theft measures or features that enhance the security of the product? How would you feel if the packaging lacks any measures to prevent theft and safeguard the product?					
Low cost	How would you feel if the packaging is designed to minimize costs and offer an inexpensive option for packaging the parts? How would you feel if the packaging does not prioritize minimizing costs and contribute to a higher product price?					
Fits in storage spaces	How would you feel if the packaging easily fits into the storage spaces? How would you feel if the packaging is bulky and difficult to fit into the storage spaces?					
Hygienic & safety	How would you feel if the packaging helps to ensure hygienic and safe use of the product? How would you feel if the packaging makes it difficult to use the product hygienically and safely?					

Source: Author.

4.5 FREQUENCY-BASED CLASSIFICATION METHOD

The Frequency-Based attributes classification method is based on the frequency of responses proposed by Kano *et al.* (1984). In this method the classification of a particular attribute is based on the maximum frequency of a response. This is called Classification Tendency and is presented on Table 7.

Table 7 - Frequency-Based attributes classification

Packaging Attribute	Attractive	Must-be	One-dim.	Indifferent	Reverse	Skeptical	Class.Tendency
Protection & preservation	0 (0%)	**11 (50%)**	**11 (50%)**	0 (0%)	0 (0%)	0 (0%)	Must-be & One-dim.
Recycled material use	**14 (64%)**	1 (5%)	2 (9%)	5 (23%)	0 (0%)	0 (0%)	Attractive
Facilitates handling and distribution	2 (9%)	**11 (50%)**	8 (36%)	1 (5%)	0 (0%)	0 (0%)	Must-be
Stackable	2 (9%)	7 (32%)	**8 (36%)**	5 (23%)	0 (0%)	0 (0%)	One-dimensional
Easy to recycle and dispose	1 (5%)	6 (27%)	**9 (41%)**	6 (27%)	0 (0%)	0 (0%)	One-dimensional
Leakage proof	2 (9%)	**10 (45%)**	**10 (45%)**	0 (0%)	0 (0%)	0 (0%)	Must-be & One-dim.
Theft-prevention	**7 (32%)**	5 (23%)	6 (27%)	3 (14%)	0 (0%)	1 (5%)	Attractive
Low cost	2 (9%)	6 (27%)	**11 (50%)**	3 (14%)	0 (0%)	0 (0%)	One-dimensional
Fits in storage spaces	0 (0%)	7 (32%)	**10 (45%)**	5 (23%)	0 (0%)	0 (0%)	One-dimensional
Hygienic & safety	0 (0%)	**9 (41%)**	**9 (41%)**	3 (14%)	0 (0%)	1 (5%)	Must-be & One-dim.

Source: Author. Number of paired answer evaluation, % in ( ).

According to the FB-classification ‘Recyled material’ use and ‘Theft-prevention’ were classified as an Attractive spare parts packaging attribute. Kano *et al.* (1996) states that customers are satisfied when Attractive attributes are fulfilled but have no feeling when not fulfilled. MacDonald *et al.* (2006) suggests including Attractive attributes at a basic functioning level, as the mere presence of the feature will induce satisfaction. Using ‘Recycled material’ and ‘Anti-theft measure’ represent unexpected features which, when presented, are seen as delighters, almost like a pleasant surprise for the customer.

‘Facilitates handing and distribution’ was classified as a Must-be attribute. Whereas ‘Protection & Preservation’, ‘Leakage proof’ and ‘Hygienic & safety’ were classified as combinations of Must-be and One-dimensional attributes. Must-be features are expected by customers, if they are not present, the product will be considered incomplete or bad. They cause dissatisfaction when not fulfilled but provide no special feeling when fulfilled (Kano *et al.* 1996). These features should be included and must function properly at an industry-standard level.

One-dimensional attributes show a proportional relation between functionality and satisfaction, whereas the increase functionality contributes to customer satisfaction. MacDonald *et al.* (2006) suggests increasing the functionality of the One-dimension attributes to the level of overcoming industry standards.

‘Stackable’, ‘Easy to recycle and dispose’, ‘Low cost’ and ‘Fits in storage spaces’ where all classified as One-dimensional spare parts packaging attribute. Investments on these packaging attributes will contribute to customer satisfaction and may represent easy wins since they are already recognized as quality in the automaker perspective.

None of the 10 spare parts attributes were classified as Indifferent, Reverse or Skeptical. This suggests that the top 10 spare parts attributes seem to be important and relevant for the dealer’s representatives.

4.6 CUSTOMER SATISFACTION COEFFICIENT METHOD

The Customer Satisfaction coefficient states whether satisfaction can be increased by meeting a product requirement, or whether fulfilling this product requirement merely prevents the customer from being dissatisfied (BERGER *et al.*, 1993). The CS-coefficient is indicative of how strongly a product feature may influence satisfaction or, in case of its non-fulfillment customer dissatisfaction (SAUERWEIN *et al*., 1996).

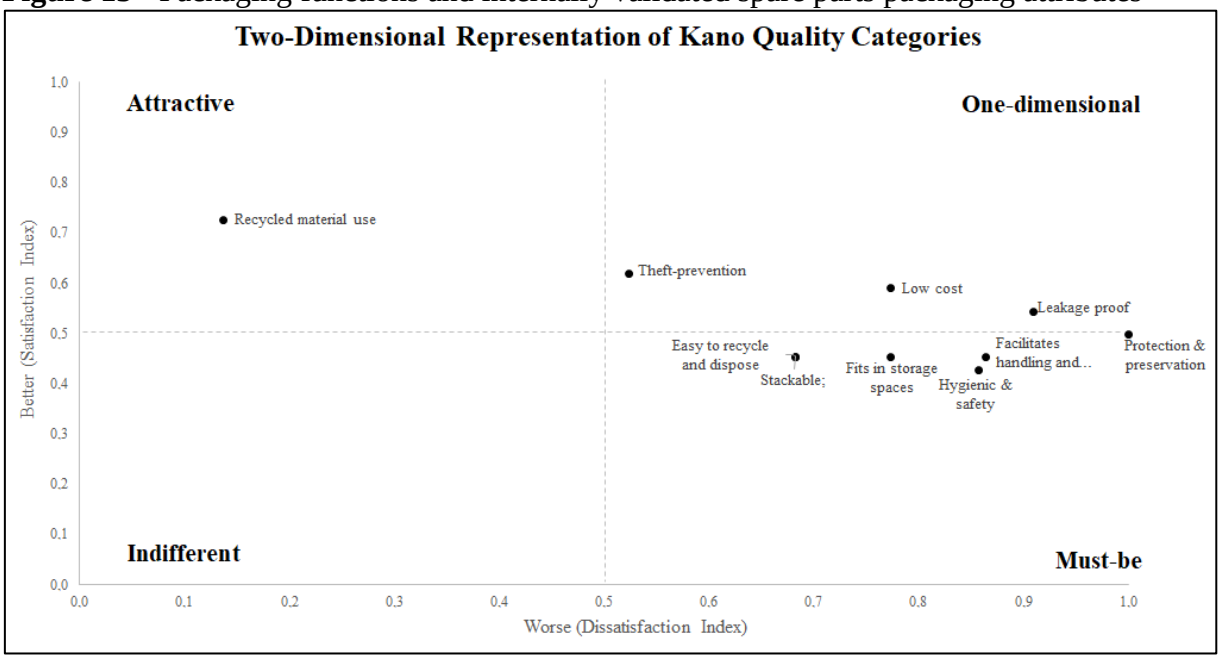
The CS-coefficient method suggests calculating two indices Satisfaction Index and Dissatisfaction Index, calculated in Table 8. The Satisfaction Index and Dissatisfaction Index varies from 0 to 1 and the 10 spare parts packaging attributes are plotted in a X-Y diagram (Figure 15) for a better visualization of the attribute classification.

Table 8 - CS-coefficient classification method

Packaging Attributes	**Y - Satisfaction index (in case of fulfillment)**			**X - Dissatisfaction index (in case of nonfulfillment)**		
	A+O	A+O+M+I	(A+O) / A+O+M+I	M+O	A+O+M+I	(A+O) / A+O+M+I
Protection & preservation	11	22	0.50	22	22	1.00
Recycled material use	16	22	0.73	3	22	0.14
Facilitates handling and distribution	10	22	0.45	19	22	0.86
Stackable	10	22	0.45	15	22	0.68
Easy to recycle and dispose	10	22	0.45	15	22	0.68
Leakage proof	12	22	0.55	20	22	0.91
Theft-prevention	13	21	0.62	11	21	0.52
Low cost	13	22	0.59	17	22	0.77
Fits in storage spaces	10	22	0.45	17	22	0.77
Hygienic & safety	9	21	0.43	18	21	0.86

Source: Author.

Figure 15 - Packaging functions and internally validated spare parts packaging attributes

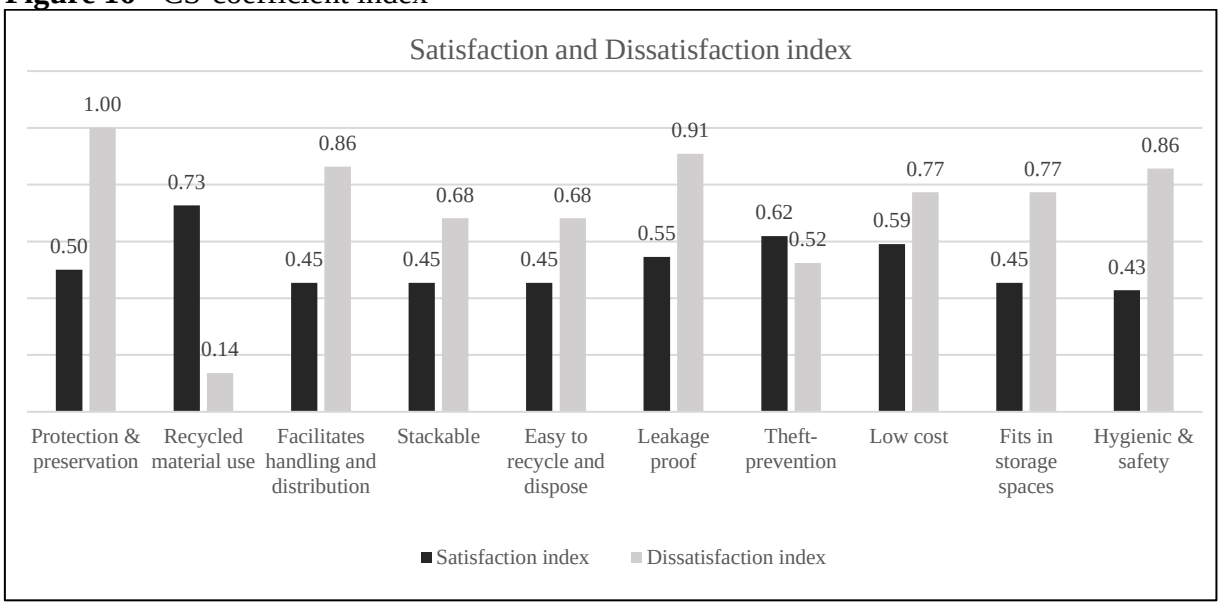


Source: Author.

According to the CS-coefficient ‘Recycled material use’ was classified as an Attractive attribute, this class of attributes can cause costumer delight. ‘Theft-prevention’, ‘Low cost’ and ‘Leakage proof’ were classified as One-dimensional features, capable of increasing customer satisfaction. Whilst ‘Easy to recycle’, ‘Stackable’, ‘Fits in storage spaces’, ‘Hygienic & safety’, ‘Facilitates handling and distribution’ were set as Must-be attributes, seen as basic features for spare parts packaging. ‘Protection & Preservation’ feature sits between One-dimension and Must-be classification.

Protection & preservation nonfulfillment achieved maximum Dissatisfaction index (1) followed by Leakage proof nonfulfillment with a 0.91 Dissatisfaction index (Figure 16). This means costumers are dissatisfied by the lack of Protection & preservation attributes and when packaging is prone to leaks or product loss. On the other hand, ‘Recycled material’ use received a 0.73 Satisfaction index followed by ‘Theft-prevention’ with 0.62. Both attributes seem to attract customer satisfaction.

Figure 16 - CS-coefficient index



Source: Author.

4.7 FB-CLASSIFICATION & CS-COEFFICIENT COMPARISON

The classifications of spare parts attributes according to the methods used FB-classification and CS-coefficient are presented on Chart 17. 'Protection & preservation', 'Recycled material use', 'Facilitates handling and distribution', and 'Low cost' have the same attribute classification in both methods. 'Leakage proof' and 'Hygienic & safety' have partially different classification because according to the FB-classification these two attributes have a combined classification (Must-be and One-dimensional). 'Stackable', 'Easy to recycle and dispose', 'Prevent theft' and 'Fits in storage spaces' have different classification approaches from FB-classification and CS-coefficient methods. Both methods agree that none of the packaging attributes were classified as Skeptical, Reverse, or Indifferent.

Chart 17 - FB-classification and CS-coefficient methods comparison

Spare Parts Pack. Attributes	FB-classification	CS-coefficient	FB *vs* CS classification
Protection & preservation	Must-be | One-dimensional	Must-be | One-dimensional	Same
Recycled material use	Attractive	Attractive	Same
Facilitates handling and distribution	Must-be	Must-be	Same
Stackable	One-dimensional	Must-be	Different
Easy to recycle and dispose	One-dimensional	Must-be	Different
Leakage proof	Must-be | One-dimensional	One-dimensional	Partially different
Theft-prevention	Attractive	One-dimensional	Different
Low cost	One-dimensional	One-dimensional	Same
Fits in storage spaces	One-dimensional	Must-be	Different
Hygienic & safety	Must-be | One-dimensional	Must-be	Partially different

Source: Author.

4.8 PACKAGING SPECIALIST INSIGHTS ON ATTRIBUTE CLASSIFICATION

A structured interview with the Packaging Development Specialist enriched the attribute classification from FB-classification and CS-coefficient methods. During this interview the FB- and CS-coefficient classification were presented to the Packaging Development Specialist, and he was asked to express his opinion regarding the classification. Subsequently, he chose his personal attribute classification which is presented on Chart 18.

Chart 18 - Packaging Development Specialist comments on attribute classification

Spare Part Packaging Attribute	Packaging Development Specialist comments	Pack. Spec. classification
Protection & preservation	If I had to choose the most important packaging attribute 'Protection & Preservation' would be chosen. I see this attribute as a Must-be feature, if we don't have it complaints pop-up promptly.	Must-be
Recycled material use	I see 'Recycled material use' as an up-coming trend and, therefore, agree with the Attractive classification. Recycled material use is also leveraged by Solid Waste National Policy.	Attractive
Facilitates handling and distribution	If the packaging is hard to handle, we will face storage and distribution difficulties, hence it is a must.	Must-be
Stackable	'Stackability' helps to optimize space, I positively react to stackability increase.	One-dimensional
Easy to recycle and dispose	Environmental awareness is a must on our corporate philosophy, being easy to recycle is a first and important step for a greener packaging.	Must-be
Leakage proof	Our packaging should not allow parts to be lost/leaked during storage and transportation, this seems like a Must-be attribute.	Must-be
Theft-prevention	Anti-counterfeit and 'Theft-prevention' are new features to auto parts packaging, we still have a lot to learn from other industries, and I understand it as an Attractive attribute, it is desirable but not a must.	Attractive
Low cost	I think 'Low cost' packaging attribute behaves as one-dimensional until a turning point, where the cheapness of the packaging starts to harm product protection. After that specific turning point, I would classify it as a reverse attribute.	One-dimensional
Fits in storage spaces	Packaging should easily fit in our storage space, so it is also a must.	Must-be
Hygienic & safety	The parts must be clean and ready for installation packaging plays an important role in promoting this safety.	Must-be

Source: Author.

According to the Packaging Development Specialist:

> The listed ten packing attributes are relevant to spare parts, thus six of them were classified as Must-be. Features like ‘Recycled material use’ ‘Theft prevention’ are new trends that will progressively be incorporated to packaging development. It seems that Low cost may have a turning point from One-dimensional to Reverse attribute, if and when, it starts to harm product protection. ‘Parts protection’ and being ‘easy to handle’ are to me the most important Must-be attributes.

‘Protection & Preservation’, ‘Facilitates handing and distribution’, ‘Leakage proof’ and ‘Hygienic & safety’ seem to be the four core spare packaging attributes, they represent the basic packaging performance being classified as Must-be attributes.

Although the two methods diverge in some attributes classification the Kano model was able to bring light, in a practical level, to important drivers for spare parts packaging development as validated by the Packaging Development Specialist (Chart 19).

Chart 19 - Spare part attribute classifications

Spare Parts Pack. Attributes	FB-classification	CS-coefficient	Pack. Spec. class.
Protection & preservation	Must-be | One-dimensional	Must-be | One-dimensional	Must-be
Recycled material use	Attractive	Attractive	Attractive
Facilitates handling and distribution	Must-be	Must-be	Must-be
Stackable	One-dimensional	Must-be	One-dimensional
Easy to recycle and dispose	One-dimensional	Must-be	Must-be
Leakage proof	Must-be | One-dimensional	One-dimensional	Must-be
Theft-prevention	Attractive	One-dimensional	Attractive
Low cost	One-dimensional	One-dimensional	One-dimensional
Fits in storage spaces	One-dimensional	Must-be	Must-be
Hygienic & safety	Must-be | One-dimensional	Must-be	Must-be

Source: Author.

4.9 SPARE PARTS PACKAGING KEY ATTRIBUTES

When categorizing the packaging attributes into dimensions, as proposed by Dash (2021), the key spare parts packaging attributes correspond to the functional and technical entities (Chart 20). The informative dimension is not seen as relevant for spare parts primary packaging and ‘Low cost’ assumes a secondary role.

Chart 20 - Packaging attribute classification, functions, and dimensions

Dimensions	Functions	Packaging attributes	Packaging Specialist attribute classification
Functional	Sustainability	Easy to recycle and dispose	Must-be
	Distribution & PE	Facilitates handling and distribution	Must-be
	Distribution & PE	Fits in storage spaces	Must-be
Technical	Sustainability	Recycled material use	Attractive
	Protection	Theft-prevention	Attractive
	Hygienic & safety	Hygienic & safety	Must-be
	Containment	Leakage proof	Must-be
	Protection & Preservation	Protection & preservation	Must-be
	Distribution & PE	Stackable	One-dimensional
Visual	Sells	Low cost	One-dimensional

Source: Author

For the continuous improvement of spare parts primary packaging, this study recommends the following attributes:

a) Must-be attributes: ‘Protection & preservation’, ‘Facilitates handling and distribution’, ‘Fits in storage spaces’, ‘Easy to recycle and dispose’, ‘Leakage proof’, and ‘Hygienic & safety’. These are related to the following core packaging function: ‘Protection and preservation’, ‘Distribution and process efficiency’, ‘Sustainability’, ‘Containment’, ‘Hygiene & safety’, and all attributes linked to technical and functional dimensions (Chart 20).

b) One-dimensional: ‘Stackable’ and ‘Low cost’. Stackability is related to ‘Distribution and process efficiency’ function while Low cost leverages influences sales.

c) Attractive attributes: ‘Recycled material use’, and to ‘Theft-prevention’. These technical dimensions reinforce aspects of ‘Sustainability’ and ‘Protection’.

According to Dash (2021), through the use of the Kano Model, packaging development should prioritize and fulfill all Must-be quality attributes. In the context of spare parts, these Must-be attributes include: ‘Protection & preservation’, ‘Facilitates handling and distribution’, ‘Fits in storage spaces’, ‘Easy to recycle and dispose’, ‘Leakage proof’, and ‘Hygienic & safety’.

Moreover, packing attributes should be competitive enough in one-dimensional category, as outlined by Dash (2021). For spare parts packaging this includes excelling in ‘Stackable’ and ‘Low cost’ attributes. Lastly, the attractive category ‘Recycled material use’

and ‘Theft-prevention’ should be given importance in packaging when aiming to delight the customers.

This study showed that, for the researched company, spare parts primary packaging should prioritize protection, distribution efficiency and sustainability. These attributes, residing in the Technical and Function dimensions, serve as basic packaging needs for spare parts.

Drawing a parallel with Dash’s (2021) research on everyday commodities, the technical dimension predominantly contains Must-be categories which indicates that the attribute has to be fulfilled, otherwise the customer will defect to competitor products. This was found to analogous to spare parts packaging. Examining food packaging Brozović *et al.* (2021) classified ‘protection’ as a combination of Must-be and One-dimensional attributes and Jagoda *et al.* (2023) classified ‘protection’ as Must-be attribute. Lima (2009) also asserts that the quality requirement ‘to preserve the integrity of the product’ is classified as a Must-be requirement in of packaging for an assembly line.

Notably, visual communication and promotional aspects were not highlighted as key attributes for spare parts primary packaging, resulting in low level of requirements. These spare part packaging drivers are in line with Purba *et al.* (2018) and Sundestrand and Sjöström (2022) results, which emphasize the focus on functional and technical packaging dimensions with discrete informative and visual appeal. Liu (2016) when studying packaging in the photoelectricity industry mentions as customer needs: packaging simplicity, easy to handle packaging, protection and being eco-friendly.

5 CONCLUSION

The aim of this dissertation was to identify spare parts packaging features, and thereafter, determine key primary packaging attributes from the perspective of an automotive manufacturer in Brazil. This research had three goals:

To determine the relevant attributes of spare parts packaging

Through a Structured Literature Review 32 distinct characteristics of packaging attributes were defined, and their descriptions and explanations are presented in Chart 14. Parts Division specialists ranked the Top 10 spare parts primary packaging attributes. In order of importance, they are: 'Protection & preservation', 'Recycled material use', 'Facilitates handling and distribution', 'Stackable', 'Easy to recycle and dispose', 'Leakage proof', 'Theft-prevention', 'Low cost', 'Fits in storage spaces', and 'Hygienic & safety'.

To classify spare parts packaging attributes using a Kano Model approach

The Top 10 spare parts primary packaging attributes were classified by Frequency-Based classification method from Kano *et al.*, (1984) and Customer Satisfaction coefficient method from Berger *et al.*, (1993). The attribute classification was then validated by the Packaging Development Specialist.

'Protection & preservation', 'Facilitates handling and distribution', 'Easy to recycle and dispose', 'Leakage proof', 'Fits in storage spaces', and 'Hygienic & safety' were classified as Must-be attributes. These features are expected by customers, if not present, the packaging will be considered bad and incomplete.

'Stackable' and 'Low cost' were classified as One-dimensional, meaning that when these attributes are fulfilled, they contribute to satisfaction, and when not fulfilled, they cause dissatisfaction.

'Recycled material use', and to 'Theft-prevention' were classified as Attractive attributes, these are unexpected features which, when presented, cause a positive reaction (delighters).

To recommend spare parts packaging key attributes

This study show that, for the researched company, spare parts primary packaging should prioritize protection, distribution efficiency and sustainability. These attributes, residing in the Technical and Function dimensions, serve as basic packaging needs for spare parts. 'Protection

& preservation' nonfulfillment achieved maximum Dissatisfaction index, this means costumers representatives are dissatisfaction by the lack of 'Protection & preservation' attributes.

Visual communication and promotional aspects were not highlighted as key functions for spare parts packaging, resulting in low level of requirements. Using 'Recycled material' and 'Anti-theft measures' represent unexpected features which, when presented, are seen as delighters, almost like a pleasant surprise for the customer.

Through use of the Kano Model this research suggests for the spare parts packaging development process to prioritize and fulfill all Must-be quality attributes: 'Protection & preservation', 'Facilitates handling and distribution', 'Fits in storage spaces', 'Easy to recycle and dispose', 'Leakage proof', and 'Hygienic & safety'. Additionally, packing attributes should be competitive enough in two one-dimensional attributes 'Stackable' and 'Low cost'. Lastly, that attractive category 'Recycled material use' and 'Theft-prevention' should be given importance in packaging when aiming to delight the customers. With the recommendations of key attributes this research contributes to spare parts primary packaging development assertiveness.

5.1 PRACTICAL CONTRIBUTION & RECOMMENDATIONS

By providing spare parts primary packaging recommendations this research may contribute to continuous packaging improvement focused on customer satisfaction. It demonstrated how the Kano Model can contribute to packaging development by classifying products attributes and features. To make the content of this study more streamlined a conclusive technical report was written as a technical product of this master program, it is available at Appendix D.

5.2 THEORETICAL CONTRIBUTION

This dissertation helps to fulfill the research gap in identifying key packaging attributes for spare parts within the Brazilian context. The Structured Literature Review was an efficient method of identifying packaging attributes and found studies that border the topic 'spare parts packaging attribute' but with a different scope and/or location (LÖFGREN; WITELL, 2005; RUNDH, 2005; DASH, 2021; PURBA *et al.*, 2018; SUNDESTRAND; JÖSTRÖM, 2022; LIMA, 2009). The structured interview with specialists narrowed the packaging attributes to those most relevant for spare parts and the Kano Model classified the key attributes. This study was a starter to better understand how spare parts packaging attributes can be driven by customer satisfaction.

When compared to everyday commodities (LÖFGREN; WITTEL, 2005) quality attributes in the technical entity were viewed as creators of attractive quality, which is different from the Must-be classification for spare parts. Dash (2021) classified informative dimension majority as must-be category which in the case of everyday commodities should be fulfilled at first priority since in this case packaging plays an important role on consumer decision during purchase. On the other hand, the informative dimension was found irrelevant for spare parts, it seems packing is not understood as a ‘silent salesman’.

Studying food products Brozović *et al.* (2021) 'Fits in storage' attribute was classified as attractive while for spare parts this is a Must-be attribute and ‘Easy to dispose’ was classified as One-dimension while for spare parts this is a must.

5.3 LIMITATIONS

This research was limited to one automotive manufacturer in Brazil, other manufacturers may have different spare part packaging approaches. The Theory of Attractive Quality (Kano, 2001) derived from the Kano Model predicts that product attributes are dynamic. In other words, spare parts packaging attributes will change over time, this study was limited to a one-year research. Direct access to dealers was not possible, thus dealers’ representatives were responsible for answering the Kano Questionnaire indirectly echoing the costumers’ voices. These scope limitations may also be seen as suggestions for further research.

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APPENDIX A - Scopus and Web of Science (WoS) databases using the search return

Ident.	Authors & (Year of Publ.)	Title	Scopus	WoS	**Incl.**	Excl.	Reason to include or exclude
A1.	Jagoda, S.U.M., Gamage, J.R., Karunathilake, H.P. (2023)	Environmentally sustainable plastic food packaging: A holistic life cycle thinking approach for design decisions	x		**x**		**Kano's theory and QFD used to identify food packaging requirements.**
A2.	Zhang, D., Shen, Z., Li, Y. (2023)	Requirement analysis and service optimization of multiple category fresh products in online retailing using importance-Kano analysis	x			x	Specific focus: fresh products
A3.	Mitrovic, M., Tomasevic, I., Djekic, I. (2022)	Quality perception throughout the table egg supply chain	x			x	Specific focus: eggs
A4.	Porto De Lima, B., Da Silva, A.F., Marins, F.A.S. (2022)	New hybrid AHP-QFD-PROMETHEE decision-making support method in the hesitant fuzzy environment: An application in packaging design selection	x		**x**		**Packaging design selection for an automotive company**
A5.	Brozović, M., Kovačević, D., Bota, J. (2021)	Consumer satisfaction with packaging materials: Kano model analysis approach	x		**x**		**Influence of packaging materials on consumers' perception of product quality**
A6.	Loučanová, E. (2021)	Perception of Zero Waste in the Context to Environmental Innovation in Slovakia	x			x	Different theme: zero-waste and non-packaging
A7.	Faishal, M., Mohamad, E., Jaafar, R., Rahman, A.A., Adiyanto, O., Jatmiko, H.A., Novera, I. (2021)	Integrated approach to customer requirement using quality function deployment and kansei engineering to improve packaging design	x			x	Specific focus: crispy wader fish
A8.	Faisha, M., Mohamad, E., Rahman, A.A.A., Desviane, S., Ramawan, A., Jamli, M.R., Adiyanto, O. (2021)	Safety and Quality Improvement of Street Food Packaging Design Using Quality Function Deployment	x			x	Specific focus: meatball
A9.	Dash, S.K. (2021)	Identifying and classifying attributes of packaging for customer satisfaction - A kano model approach	**x**	**x**	**x**		**Perception of the customers on 22 quality attributes of packaging using Kano**
A10.	Meráz-Rivera, J., Cruz-Rivero, L., Méndez-Hernández, M.L., Rivera-Armenta, J.L., Angeles-Herrera, D., Ramírez-López, C. (2020)	Development of a composite from TPS-EVOH-SBR reinforced with coconut fiber	x	x		x	Specific focus: packaging made of coconut fiber for food contact
A11.	Rizzo, P.V., Harwood, W.S., Drake, M.A. (2020)	Consumer desires and perceptions of lactose-free milk	x			x	Specific focus: lactose-free dairy milk

(*cont.*) APPENDIX A - Scopus and Web of Science (WoS) databases using the search return

Ident.	Authors & (Year of Publ.)	Title	Scopus	WoS	**Incl.**	Excl.	Reason
A12.	Loučanová, E., Nosáľová, M., Olšiaková, M. (2019)	The development of the innovation status and impact of smart packaging on Slovak consumers	x			x	Different theme: smart packaging
A13.	Speight, K.C., Schiano, A.N., Harwood, W.S., Drake, M.A. (2019)	Consumer insights on prepackaged Cheddar cheese shreds using focus groups, conjoint analysis, and qualitative multivariate analysis	x	x		x	Specific focus: cheddar cheese
A14.	Djekic, I; Radivojevic, D; Milivojevic, J. (2019)	Quality perception throughout the apple fruit chain		x		x	Specific focus: apple
A15.	Kim, J.S. (2018)	Measuring willingness-to-pay for mobile phone features: a multi-region study	x	x		x	Different theme: Mobile phone's attributes
A16.	Liu, S.-F., Cheng, J.-H., Lee, Y.-L., Gau, F.-R. (2016)	A case study on FMEA-based quality improvement of packaging designs in the TFT-LCD industry	x		**x**		**Package design for semi-finished products using QFD**
A17.	Rukmayadi, D., Marimin, Haris, U., Yani, M. (2016)	Rubber agro-industry green logistic conceptual model	x			x	Different theme: Agro-Industry green logistic
A18.	Hubbard, E.M., Jervis, S.M., Drake, M.A. (2016)	The effect of extrinsic attributes on liking of cottage cheese	x			x	Specific focus: cottage cheese
A19.	Wardy, W., Mena, B., Nongtaodum, S., No, H.K., Prinyawiwatkul, W. (2014)	Exploring the Drivers of Purchase Intent and Consumer Satisfaction of Chicken Eggs Using Principal Component Analysis and the Kano Model	x			x	Specific focus: eggs
A20.	Cannoosamy, K., Pugo-Gunsam, P., Jeewon, R. (2014)	Consumer knowledge and attitudes toward nutritional labels	x			x	Different theme: nutritional labels
A21.	Chen, J.C.-C. (2014)	The impact of nostalgic emotions on consumer satisfaction with packaging design	x			x	Different theme: packaging nostalgic emotions
A22.	Dill, M.D., Revillion, J.P.P., Barcellos, J.O.J., Dias, E.A., Mércio, T.Z., de Oliveira, T.E. (2014)	Procedural priorities of the pork loin supply chain	x			x	Specific focus: pork loin
A23.	Kim, M.K., Lopetcharat, K., Drake, M.A. (2013)	Influence of packaging information on consumer liking of chocolate milk	x	x		x	Specific focus: chocolate milk

Source: Author.

APPENDIX B - Structured questionnaire for internal survey

Packaging attribute	**Level of agreement**														
Easy to grip	5	5	4	4	5	4	4	5	4	4	4	4	4	4	3
Easy to open & use	5	5	4	5	4	4	4	2	4	3	3	5	4	4	4
Easy to empty completely	5	5	5	4	3	4	4	4	5	2	4	4	4	4	4
Easy to dose	5	5	5	5	4	4	5	5	4	2	2	4	4	4	5
User-friendly & Convenience	5	4	4	4	4	3	3	4	3	4	3	5	5	4	4
Reusable	5	5	3	5	3	5	2	4	5	5	4	5	4	4	3
Easy to recycle and dispose	5	5	4	5	5	4	5	5	4	5	5	5	4	4	3
Facilitates handling and distribution	5	5	5	4	5	4	4	5	5	5	5	5	5	4	4
Fits in storage spaces	5	5	5	4	5	4	2	5	4	3	5	4	4	4	5
Right size, quantity or weight	5	5	5	5	4	4	5	5	4	2	4	5	2	4	4
Additional Functions & Innovation	5	3	3	4	4	3	1	4	5	1	3	5	4	4	2
Protection & preservation	5	5	5	5	5	5	5	5	5	5	5	4	5	4	5
Strong packaging	5	2	5	5	3	5	5	5	4	5	4	5	4	3	3
Theft-prevention	5	4	5	3	3	4	4	5	5	5	4	5	5	5	4
Resealability:	5	2	5	4	4	4	1	4	2	2	3	5	4	4	3
Stackable:	5	4	5	4	5	5	5	5	5	4	5	4	4	4	5
Hygienic & safety	5	4	5	4	4	4	5	5	4	4	3	5	4	4	4
Leakage proof	5	5	5	5	5	4	5	4	5	4	4	3	5	4	5
Recycled material use	5	5	5	5	4	4	5	5	5	5	5	5	5	5	3
Unique and hard to copy	5	3	4	3	3	4	4	4	3	1	3	5	2	4	3
Customer care number	5	3	4	2	4	4	4	5	4	3	5	4	5	4	4
Date of manufacturing	5	5	4	3	4	4	4	4	3	4	4	3	2	4	4
Declaration of contents	5	4	5	4	4	4	1	2	2	3	3	3	3	4	4
Instructions	5	3	5	2	3	2	2	2	1	2	1	2	4	4	4
Open-dating information	5	3	5	4	4	3	3	5	2	2	3	4	2	5	4
URL & external links	4	2	4	2	3	4	5	3	3	2	5	2	4	4	3
Symbols	4	5	5	3	3	4	5	5	4	5	5	2	4	4	4
Aesthetically appealing	4	2	3	4	4	3	5	3	3	1	4	2	3	3	3
Branding & Appearance	4	4	5	4	4	4	4	5	3	3	5	4	4	4	4
Communicates Quality	4	3	4	4	3	4	5	5	3	4	4	4	4	3	4
Sells	4	4	3	4	4	2	1	4	2	2	4	5	4	4	4
Low cost	4	5	4	4	4	5	5	5	3	5	4	4	4	4	5
Other packaging attribute you would like to add?	None	None	None	None	None	None	None	None	Built-in carrying handles	None	None	None	None	None	QR code for additional information
Would you suggest the exclusion of any listed packaging attribute?	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
Current area or department	Procurement	Cost Management	Project Planning	Indirect material planning	Supply chain	Product development	Marketing	Demand Planning	Financial	Quality	Logistics	Purchasing	Import and Export	Transportation planning	New Products Development
Years of automotive experience	7	25	5	12	6	9	12	3	12	5	5	8	17	12	12

Source: Author.

APPENDIX C - Answers to Kano Questionnaire and attribute evaluation

ID	Protection & preservation	Recycled material use	Facilitates handling and distribution	Stackable	Easy to recycle and dispose	Leakage proof	Theft-prevention	Low cost	Fits in storage spaces	Hygienic & safety
1	MB | DNL = M	MB | DNL = M	MB | DNL = M	MB | DNL = M	MB | DNL = M	MB | DNL = M	MB | DNL = M	MB | DNL = M	MB | DNL = M	MB | DNL = M
2	LK | DNL = O	LK | AC = A	LK | DNL = O	LK | DNL = O	LK | AC = A	LK | DNL = O	LK | AC = A	LK | DNL = O	LK | DNL = O	LK | DNL = O
3	LK | DNL = O	NF | NF = I	LK | DNL = O	LK | DNL = O	NF | NF = I	LK | DNL = O	LK | DNL = O	LK | DNL = O	LK | DNL = O	LK | DNL = O
4	LK | DNL = O	LK | AC = A	LK | DNL = O	LK | AC = A	LK | DNL = O	LK | DNL = O	LK | AC = A	LK | DNL = O	LK | DNL = O	LK | DNL = O
5	MB | DNL = M	LK | AC = A	MB | DNL = M	LK | AC = A	MB | DNL = M	MB | DNL = M	LK | AC = A	MB | AC = I	MB | AC = I	MB | DNL = M
6	AC | DNL = M	LK | AC = A	MB | AC = I	MB | DNL = M	MB | DNL = M	MB | DNL = M	NF | AC = I	MB | DNL = M	MB | AC = I	MB | DNL = M
7	MB | DNL = M	LK | NF = A	MB | DNL = M	LK | DNL = O	NF | AC = I	MB | DNL = M	LK | NF = A	LK | DNL = O	MB | DNL = M	MB | DNL = M
8	MB | DNL = M	AC | AC = I	MB | DNL = M	AC | AC = I	NF | NF = I	MB | DNL = M	MB | DNL = M	MB | DNL = M	MB | DNL = M	MB | DNL = M
9	MB | DNL = M	LK | AC = A	MB | DNL = M	MB | DNL = M	LK | DNL = O	MB | DNL = M	LK | DNL = O	LK | AC = A	MB | DNL = M	LK | DNL = O
10	MB | DNL = M	LK | AC = A	MB | DNL = M	LK | DNL = O	LK | DNL = O	LK | AC = A	MB | DNL = M	MB | DNL = M	LK | DNL = O	MB | DNL = M
11	MB | DNL = M	MB | NF = I	LK | AC = A	MB | DNL = M	MB | AC = I	MB | DNL = M	MB | NF = I	LK | AC = A	MB | DNL = M	MB | DNL = M
12	MB | DNL = M	LK | AC = A	MB | DNL = M	LK | DNL = O	LK | DNL = O	LK | DNL = O	LK | DNL = O	MB | DNL = M	MB | DNL = M	MB | DNL = M
13	MB | DNL = M	LK | AC = A	LK | DNL = O	MB | DNL = M	MB | DNL = M	LK | DNL = O	LK | AC = A	LK | DNL = O	LK | DNL = O	MB | DNL = M
14	LK | DNL = O	LK | AC = A	MB | DNL = M	MB | AC = I	MB | NF = I	MB | DNL = M	MB | AC = I	LK | DNL = O	MB | AC = I	MB | AC = I
15	LK | DNL = O	LK | NF = A	LK | DNL = O	LK | DNL = O	LK | DNL = O	LK | DNL = O	LK | DNL = O	MB | AC = I	LK | DNL = O	LK | DNL = O
16	LK | DNL = O	NF | NF = I	MB | DNL = M	MB | AC = I	MB | DNL = M	LK | DNL = O	LK | AC = A	LK | DNL = O	MB | AC = I	NF | NF = I
17	LK | DNL = O	MB | AC = I	MB | DNL = M	MB | AC = I	MB | AC = I	MB | DNL = M	MB | DNL = M	NF | NF = I	MB | AC = I	MB | AC = I
18	LK | DNL = O	LK | DNL = O	LK | DNL = O	LK | DNL = O	LK | DNL = O	LK | DNL = O	LK | DNL = O	LK | DNL = O	LK | DNL = O	LK | DNL = O
19	MB | DNL = M	LK | NF = A	MB | DNL = M	MB | DNL = M	MB | DNL = M	MB | DNL = M	LK | AC = A	MB | DNL = M	MB | DNL = M	LK | DNL = O
20	LK | DNL = O	LK | NF = A	LK | DNL = O	MB | DNL = M	LK | DNL = O	LK | NF = A	LK | LK = S	LK | DNL = O	LK | DNL = O	LK | DNL = O
21	LK | DNL = O	LK | AC = A	LK | AC = A	NF | NF = I	LK | DNL = O	LK | DNL = O	MB | DNL = M	LK | DNL = O	LK | DNL = O	LK | LK = S
22	LK | DNL = O	LK | DNL = O	LK | DNL = O	LK | DNL = O	LK | DNL = O	LK | DNL = O	LK | DNL = O	LK | DNL = O	LK | DNL = O	LK | DNL = O

Source: Author.

Functional Question | Dysfunctional Question = Requirement Evaluation

LK (like); MB (Must-be); NF (No feeling); AC (Acceptable); DNL (Do not like)

Skeptical (S); Attractive (A); Reverse (R); Indifferent (I); Must-be (M)

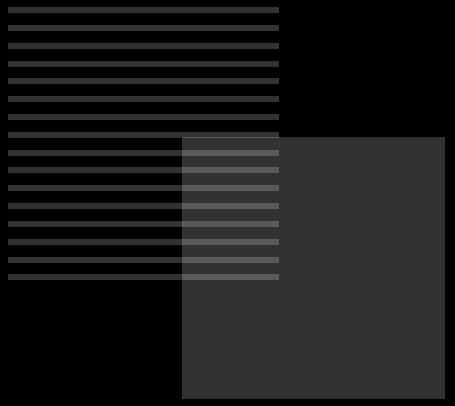
APPENDIX D - CONCLUSIVE TECHNICAL REPORT FOR SPARE PARTS PACKAGING

ATTRIBUTES FOR

SPARE PARTS PACKAGING:

A KANO APPROACH

A conclusive technical report
prepared by **Thiago Karaski**



Universidade Federal de São Carlos
PPGPEP - 2024

(*cont.*) APPENDIX D - Conclusive technical report for spare parts packaging

Conclusive Report for Spare Parts Packaging

Conclusive technical report

Purpose Description : The aim of this report is to identify spare parts packaging attributes and determine key primary packaging attributes from the perspective of an automotive manufacturer in Brazil.

Technological advances/degree of novelty : Production with a medium innovative content: combines pre-established knowledge (Kano model) to spare parts packaging.

Social and/or economic impact: Contributes to spare parts primary packaging development assertiveness.

Permanent Professor: Dr. Fabiane Letícia Lizarelli / **Student Author:** Thiago Urtado Karaski - Master's Degree

Research project linked to production: Production Engineering / **Line of Research linked to production**: Quality

Connection with Scientific Production
Title: Spare parts packaging attributes: a case study in an automaker in Brazil
Periodical: Simpósio Acadêmico de Engenharia de Produção (SAEPRO) from EEL-USP
Others: 2023; 28 pages; ISBN: 978 -85-5722-847-4

Applicability of Technological Production: High applicability
Description of the Scope: spare parts packaging of an automotive manufacturer in Brazil
Description of Potential Scope: other automotive manufacturers or other regions
Description of Replicability: key attributes identification and the use of the Kano Model is highly replicable

Content: Introduction, Research Method, Results, Discussion, and Conclusion.

(*cont.*) APPENDIX D - Conclusive technical report for spare parts packaging

Conclusive Report for Spare Parts Packaging

Introduction

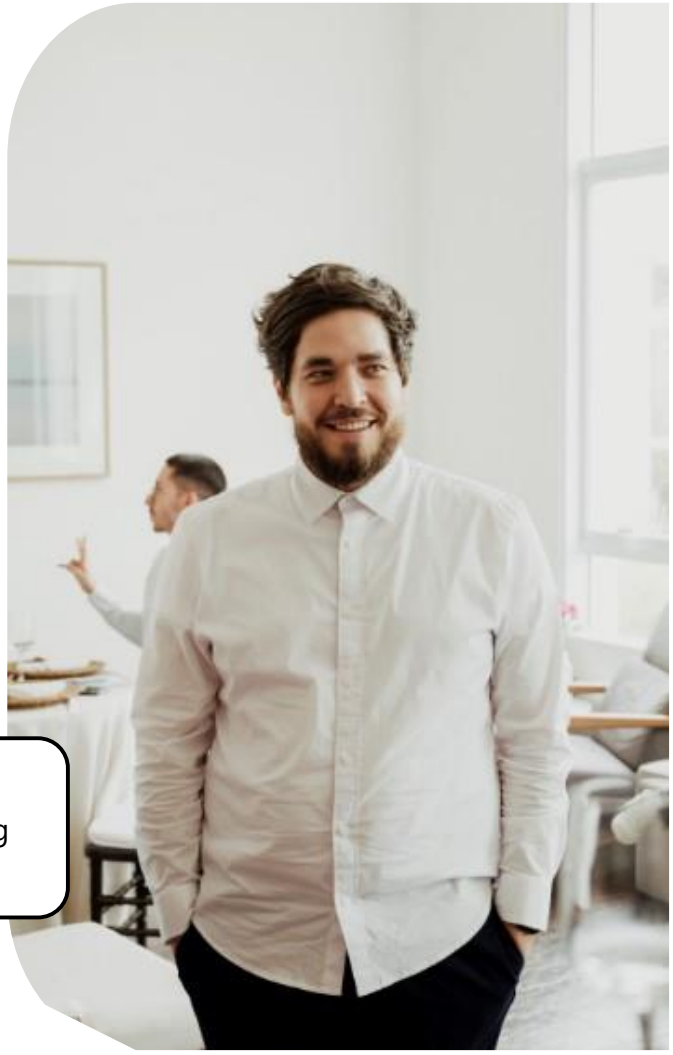
Both automobile and motorcycle owners will need to replace a part or perform periodic maintenance during the product's useful life.

Spare part packaging plays an important role in assuring product quality maintenance during internal logistics, storage, picking, delivery and part use.

This handbook aims to introduce you to the attributes andfeatures of spare part packaging

A scientific approach to understand spare parts packaging

Determine key primary packaging attributes



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Research Questions

Research gap on how spare parts packaging attributes are perceived by dealers in Brazil

Research Questions 01		What are the relevant attributes of spare parts packaging?
Research Questions 02		How to classify spare parts packaging attributes using the Kano Model?
Research Questions 03		Can we recommend spare parts packaging key quality attributes?

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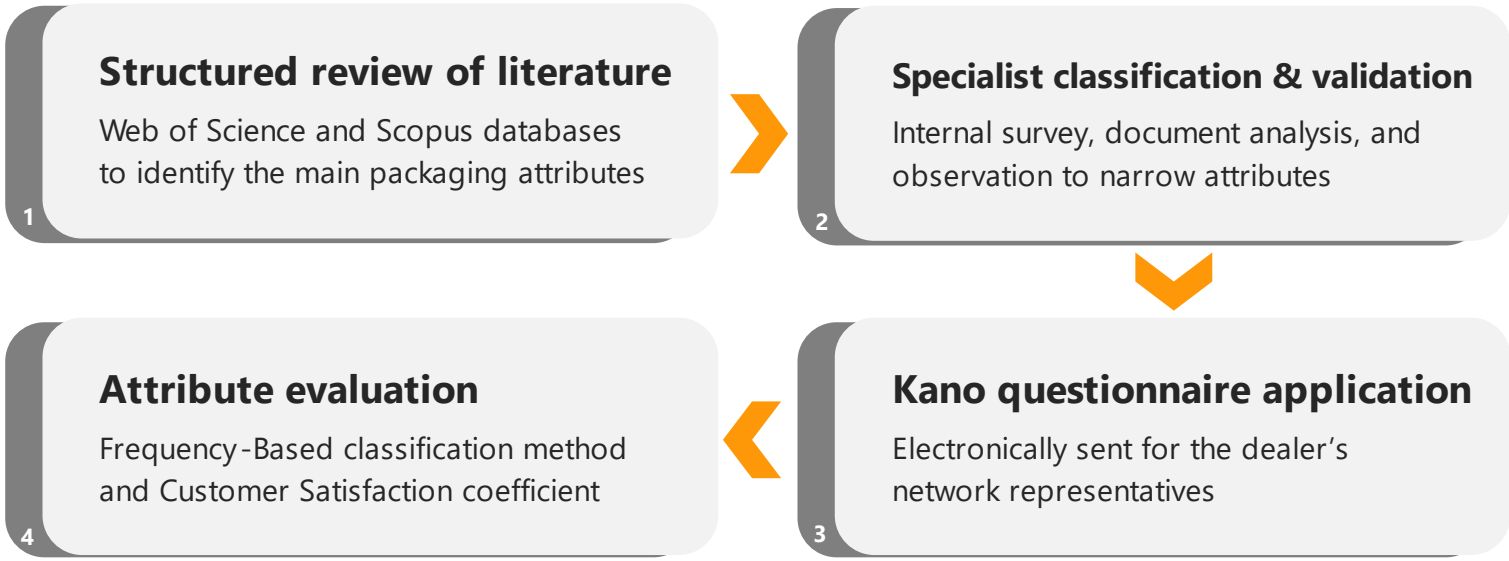
Research framework & Methods

Steps to better understand spare parts packaging



Goal: to determine spare parts packaging relevant attributes and classify them based on the Kano Model. Recommend key primary packaging attributes.

Kano Model

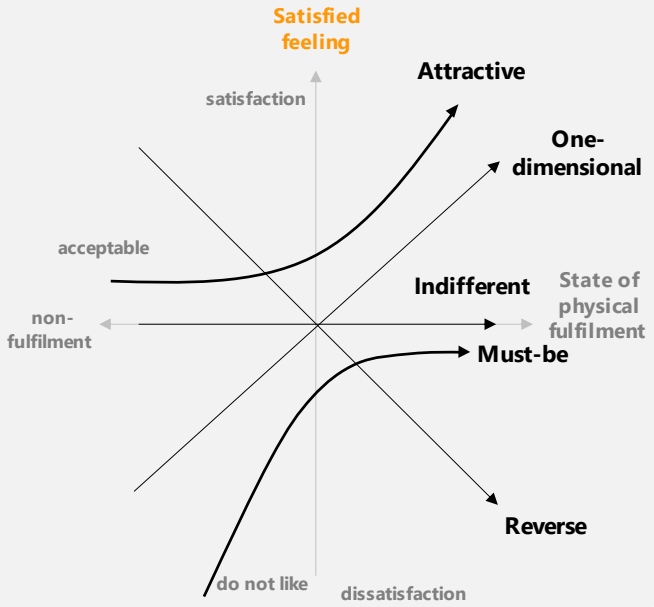
The Kano Model[1] explores the way in which a product attribute affects customer satisfaction

Displays the relationship between

The physical fulfillment of a quality attribute on a product and the perceived satisfaction of that attribute.

Attractive	Unexpected features which, when presented, cause a positive reaction
Must-be	Expected by customers, if not present, the product will be considered bad
One-dimensional	Every increase in functionality leads to increased satisfaction
Indifferent	Costumers feel indifferent, their presence (or absence)
Reverse	Opposite to the direction of efforts

Categorizing quality elements



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Packaging attributes

Structured review of literature[2] and importance ranked by Spare Parts Specialists

Protection & preservation 01	Fits in storage spaces 09	Easy to empty completely 17	Resealability 25
Recycled material use 02	Hygienic & safety 10	Branding & Appearance 18	Additional Functions & Innovation 26
Facilitates handling and distribution 03	Easy to grip 11	Easy to open & use 19	Unique and hard to copy 27
Stackable 04	Easy to dose 12	Customer care number 20	Declaration of contents 28
Easy to recycle and dispose 05	Right size, quantity or weight 13	User-friendly & Convenience 21	Sells 29
Leakage proof 06	Strong packaging 14	Communicates Quality 22	URL & external links 30
Theft-prevention 07	Reusable 15	Date of manufacturing 23	Aesthetically appealing 31
Low cost 08	Symbols 16	Open-dating information 24	Instructions 32

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Packaging attributes

Top 10 validated with Packaging Development Specialists

Protection & preservation	01	I see part protection as the packaging core function. If the packaging fails to preserve parts quality other packaging attributes become minor details.
Recycled material use	02	Although the use of recycled content is always considered during packaging development I was (personally) surprised to see this topic with such great relevance.
Facilitates handling and distribution	03	Spare parts packaging must facilitate handling and distribution as it is crucial for lean logistics. After part protection, I consider handling and distribution the second most important packaging attribute.
Stackable	04	We suffer from lack of space in the Warehouse, during picking and finaldistribution. Therefore, our packaging should be stackable when possible.
Easy to recycle and dispose	05	Environmental awareness and waste consciousness are vivid concerns not only at the Warehouse but also among the dealer network. We audit our dealers regarding environmental management in the workshops.

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Packaging attributes

Top 10 validated with Packaging Development Specialist

Leakage proof	06	Packaging can prevent the presence of rust, dust, and oil stains on our parts. Our packaging should not allow parts to be lost/leaked during storage and transportation.
Theft-prevention	07	Packaging correct closure and the use of double-walled full flaps may help prevent theft during distribution. Anti -counterfeit initiatives tend to hinder piracy and allows for product originality checks.
Low cost	08	Packaging cost is thoroughly managed but is not cut down over (in detriment of) parts protection.
Fits in storage spaces	09	Packaging should easily fit in our storage space and be safely picked.
Hygienic & safety	10	The parts must be clean and ready for installation and packaging helps with that. Ergonomic standards also apply to packaging.

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Kano questionnaire

20 questions asking dealer's representatives how would they feel if the packaging

Packaging Attribute	Questionnaire	Like	Mustbe	No feeling	Acceptable	Do not like
Protection & preservation	Provides excellent protection and preserves parts quality?	x				
	Does not protect the part adequately and compromises its quality?					x
Recycled material use	Made of recycled materials, contributing to sustainability?	x				
	Not made of recycled materials and does not contribute to sustainability?				x	
Facilitates handling and distribution	Facilitates easy handling and distribution of the parts?		x			
	Hinders the handling and distribution of the parts?					x
Stackable	Is designed to be stackable, allowing for efficient storage?		x			
	Cannot be stacked, leading to an inefficient storage?					x
Easy to recycle and dispose	Is easy to dispose of and recycle?	x				
	Is difficult to dispose of and recycle?					x
Leakage proof	Is leak-proof, preventing product loss?	x				
	Is prone to leaks or product loss?					x
Theft-prevention	Includes anti-theft measures or features that enhance the security of the product?	x				
	Lacks any measures to prevent theft and safeguard the product?					x
Low cost	Is designed to minimize costs and offer an inexpensive option for packaging the parts?	x				
	Does not prioritize minimizing costs and contribute to a higher product price?					x
Fits in storage spaces	Easily fits into the storage spaces?		x			
	Is bulky and difficult to fit into the storage spaces?					x
Hygienic & safety	Helps to ensure hygienic and safe use of the product?		x			
	Makes it difficult to hygienically and safely use the product?					x

Most frequent answer

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Kano Model: Frequency-Based classification method[3]

Classification of a particular attribute is based on the maximum frequency of response

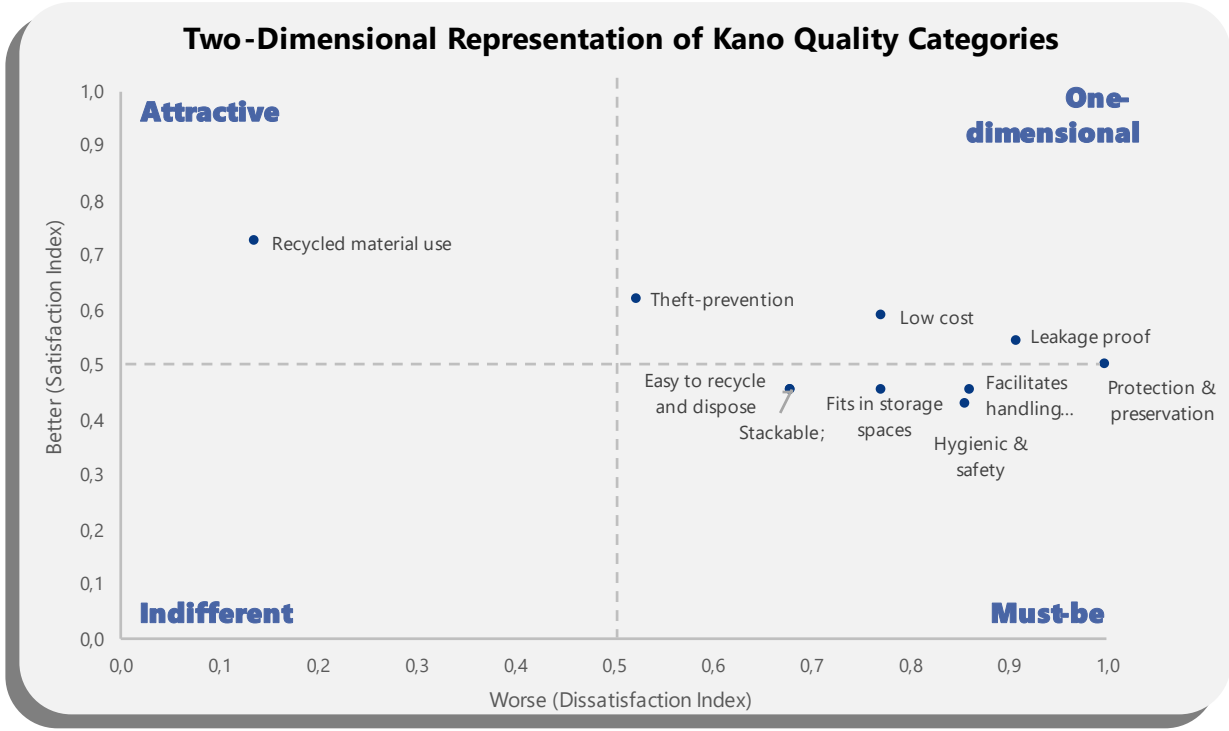
Packaging Attribute	Attractive	Must-be	One-dim.	Indifferent	Reverse	Skeptical	Classification Tendency
Protection & preservation	0 (0%)	**11 (50%)**	**11 (50%)**	0 (0%)	0 (0%)	0 (0%)	**Must-be & One-dim.**
Recycled material use	**14 (64%)**	1 (5%)	2 (9%)	5 (23%)	0 (0%)	0 (0%)	**Attractive**
Facilitates handling and distribution	2 (9%)	**11 (50%)**	8 (36%)	1 (5%)	0 (0%)	0 (0%)	**Must-be**
Stackable	2 (9%)	7 (32%)	**8 (36%)**	5 (23%)	0 (0%)	0 (0%)	**One-dimensional**
Easy to recycle and dispose	1 (5%)	6 (27%)	**9 (41%)**	6 (27%)	0 (0%)	0 (0%)	**One-dimensional**
Leakage proof	2 (9%)	**10 (45%)**	**10 (45%)**	0 (0%)	0 (0%)	0 (0%)	**Must-be & One-dim.**
Theft-prevention	**7 (32%)**	5 (23%)	6 (27%)	3 (14%)	0 (0%)	1 (5%)	**Attractive**
Low cost	2 (9%)	6 (27%)	**11 (50%)**	3 (14%)	0 (0%)	0 (0%)	**One-dimensional**
Fits in storage spaces	0 (0%)	7 (32%)	**10 (45%)**	5 (23%)	0 (0%)	0 (0%)	**One-dimensional**
Hygienic & safety	0 (0%)	**9 (41%)**	**9 (41%)**	3 (14%)	0 (0%)	1 (5%)	**Must-be & One-dim.**

Source: Author. Number of paired answer evaluation, % in ( ).

(*cont.*) APPENDIX D - Conclusive technical report for spare parts packaging

Kano Model: Customer Satisfaction coefficient[4]

How strongly a feature may influence satisfaction or dissatisfaction



Source: Author.

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Findings

Reviewed by Packaging Development Specialist

Must-be

Expected by costumer

- Protection & preservation 01
- Facilitates handling and distribution 02
- Easy to recycle and dispose 03
- Leakage proof 04
- Fits in storage spaces 05
- Hygienic & safety 06

One Dimensional

Functionality increase leads to satisfaction increase

- Stackable 01
- Low cost* 02

'Low cost' attribute behaves as one-dimensional until a turning point, where the cheapness of the packaging starts to harm product protection.

After that specific turning point, I would classify it as a reverse attribute.

Attractive

Pleasant surprise

- Recycled material use 01
- Theft-prevention 02

I see 'Recycled material use' as an up-coming trend and, therefore, agree with the Attractive classification.

'Anti-counterfeit and theft' are new features and I understand, it is desirable but not a must.

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Findings

Must-be attributes Reviewed by Packaging Development Specialist

Protection & preservation	01	If I had to choose the most important packaging attribute 'Protection & Preservation' would be chosen. I see this attribute as a Must -be feature, if we don't have it complaints pop-up promptly.
Facilitates handling and distribution	02	If the packaging is hard to handle, we will face storage and distribution difficulties, hence it is a must.
Easy to recycle and dispose	03	Environmental awareness is a must on our corporate philosophy, being easy to recycle is a first and important step for a greener packaging.
Leakage proof	04	Our packaging should not allow parts to be lost/leaked during storage and transportation, this seems like a Must-be attribute.
Fits in storage spaces	05	Packaging should easily fit in our storage space, so it is also a must.
Hygienic & safety	06	The parts must be clean and ready for installation packaging plays an important role in promoting this safety.

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INTRO. THEORY METHOD RESULTS CONCL.

Recommendations

For spare parts packaging key attributes

Protection

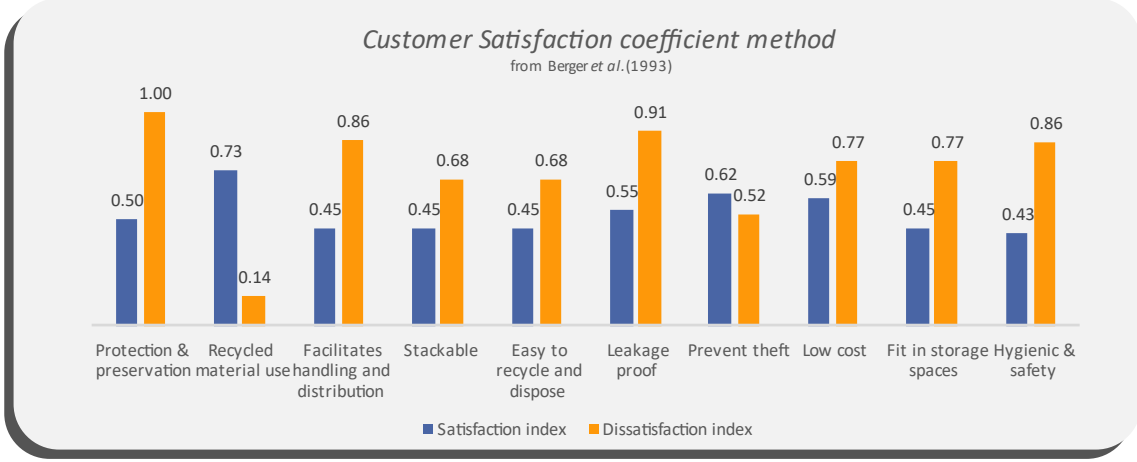
Protection & Preservation are core requirements

Dist. Efficiency

Easy to handle, distribute, store and use packaging

Sustainability

Easy to recycle and dispose and Recycled material use



73%

Satisfaction index with **Recycled material** use

100%

Dissatisfaction index in case of **protection** & preservation **nonfulfillment**

Primary spare parts packaging should prioritize protection, distribution efficiency and sustainability.
Visual communication and promotional aspects were not highlighted as key attributes, resulting in low level of requirements.

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Conclusion

First step towards understanding spare part packaging requirements:

- 32 Packaging attributes
- Kano Class.
  - 6 Must-be
  - 2 Attractive
  - 2 One-dimensional
- Focus on protection, distribution efficiency and sustainability

Contributes to spare parts primary packaging development assertiveness.

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Research Limitations

This research has limitation which may also be seen as suggestions for further research

Time

Theory of Attractive Quality[5] predicts that attributes are dynamic.

Spare parts packaging attributes will change over time.

Object of study

Limited to one automotive manufacturer in Brazil.

Other manufacturers may have different spare part packaging approach.

Scope

Direct access to dealers was not possible.

End-user may have a different packaging approach.

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Abstract

For the complete research please search 'Karaski' @ https://repositorio.ufscar.br/

The aim of this dissertation was to identify spare parts packaging attributes, and thereafter, determine key primary packaging attributes from the perspective of an automotive manufacturer in Brazil. This was done by reviewing the literature for packaging attributes, ranking the attributes with specialists, and surveying customers representatives using a Kano approach. Additionally interviews with the Packaging Development Specialist deepen the discussion on the results. This research recommends prioritizing and fulfilling all Must-be quality attributes in spare parts primary packaging: 'Protection & preservation', 'Facilitates handling and distribution', 'Fits in storage spaces', 'Easy to recycle and dispose', 'Leakage proof', and 'Hygienic & safety'. Additionally, packing attributes should be competitive enough in two one-dimensional attributes 'Stackable' and 'Low cost'. Lastly, that attractive category 'Recycled material use' and 'Theft-prevention' should be given importance in packaging to delight the customers. For the researched company spare parts primary packaging should prioritize protection, distribution efficiency and sustainability. These attributes, residing in the Technical and Function dimensions, serve as basic packaging needs for spare parts.

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