People's Democratic Republic of Algeria.
Ministry of Higher Education and Scientific Research.
A. MIRA University - Bejaia.

Faculty of Natural and Life Sciences.

Department of Food Science.

Major: food preservation and packaging.

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Master's Thesis

In order to obtain a Master's degree
in Food Conservation and Packaging.

Theme:

Production and Transformation of corrugated cardboard for the agri-food sector (Case of secondary pasta packaging)

Presented By:

Mehdi Takka

Before a committee composed of:

Mr. Kati Djamel Eddine	Supervisor
Mr. Baudouin Fares	President
Mme. Benmerad Chadia	Examinator

Academic year: 2022 / 2023

MAGHREB EMBALLAGE .1948.

جامعة بجاية
Tasdawit n Bgayet
Université de Béjaïa

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Thanks

I would like to express my heartfelt gratitude to Allah, the Most Merciful and the Most Gracious, for granting me the strength, guidance, and blessings throughout this journey.

To my beloved family, especially my mom and dad, your unwavering support, love, and encouragement have been the foundation of my success. I am truly grateful for everything you have done for me.

I want to dedicate an extra special thank you to my cousins Hachemi and Rachid Takka. Your unwavering support, guidance, and connections have played a significant role in my journey, and I am forever grateful for the opportunities you have allowed me to reach.

I would also like to extend my sincere appreciation to the entire team at Maghreb Emballage, who played an integral role in making this project a reality. In particular, I am grateful to Abd-eldjalil and Adam Meradi for their invaluable guidance, expertise, and unwavering support throughout the project.
My deepest gratitude goes to my mentor, Prof Djamel-Eddine Kati, whose guidance, wisdom, and encouragement have been instrumental in shaping my understanding and growth in this field. I am truly grateful for your dedication and expertise.

Lastly, I would like to express my gratitude to all the teachers who have played a part in my education and contributed to my knowledge and development. Your dedication and passion for teaching have laid the foundation for my success.
Thank you all for being a part of my journey and for your support, encouragement, and belief in me. I am forever grateful and blessed to have such wonderful individuals in my life.

Mehdi Takka

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List of abbreviations

mm: Millimeter.

cm: centimeter.

m: meter.

f/m: folds per Meter.

g/m^2: Gram per Meter squared.

Kg: Kilogram.

mPas: millipascal-seconds.

°C: Degrees Celsius.

N: Newton.

s: Seconds.

m/min: Meter per Minute.

KN/m^2: Kilo-Newton per Meter-Squared.

BCT: Box Crush Test.

CMYK: Cyan, Magenta, Yellow, and Key (Black).

BLS: BLANCO SAICA LINER.

HS: HIDROSAICA Medium (fluting).

DS: DUOSAICA Liner.

QR: Quick Response Code.

SPA: short for the French word “Société Par Actions” meaning a joint-stock company.

BC: before Christ.

ME: Maghreb Emballage.

EMB: short for “EMBALLAGE”, French for “Packaging

INTRODUCTION

I Introduction

The packaging industry plays a crucial role in protecting and preserving products, enhancing their marketability, and minimizing waste.

In response to growing environmental concerns, there has been a heightened emphasis on adopting sustainable packaging solutions. Corrugated cardboard has emerged as a viable and environmentally friendly alternative due to its recyclable nature, renewability, and versatility. being a widely utilized packaging material, corrugated cardboard holds significant potential for minimizing the environmental impact across various industries, particularly in the food sector.

Maghreb Emballage SPA, the company where I completed my internship, operates within the packaging industry and deals with the production and transformation of corrugated cardboard. This first-hand experience within the company provides a unique perspective and valuable insights into the specific challenges, practices, and innovations related to the packaging sector, during this internship my goal was to:

- delve into the intricacies of producing cardboard boxes designed for secondary pasta packaging.
- Additionally, get to know the various quality tests conducted throughout the production process.

The findings of this research will contribute to the development of sustainable packaging practices, ensuring that the cardboard packaging meets the required quality standards while minimizing its environmental impact.

So, what are the key steps involved in the production of secondary pasta packaging made from corrugated cardboard? And What are the critical quality parameters and testing methods used to ensure the integrity and performance of corrugated cardboard pasta packaging?

LITERATURE

II Pasta

II.1 Definition of pasta

Pasta refers to a staple food made from unleavened dough consisting of wheat flour and water, or sometimes eggs that is typically cooked by boiling. A versatile food product enjoyed in various cultures worldwide and comes in numerous shapes, sizes, and textures. Common shapes include spaghetti, penne, macaroni, linguine, fettuccine, and many more. Once shaped, the pasta is usually dried to remove moisture, which contributes to its extended shelf life.

Pasta is valued for its nutritional composition, as it is a good source of complex carbohydrates, providing energy for the body. It also contains small amounts of protein, dietary fiber, and various minerals, depending on the type of flour used in its preparation. Additionally, whole wheat or whole grain pasta options are available, which retain more of the grain's natural nutrients and dietary fiber.

Pasta has a long history, with origins traced back to ancient civilizations such as the Etruscans and Romans **[1]**.

It has since become an integral part of many culinary traditions and is enjoyed by people of all ages and backgrounds around the world, this includes Algeria where the production of pasta has skyrocketed in the last few years. The chart below (figure 1) shows the production of pasta in Algeria from 2009 to 2020.

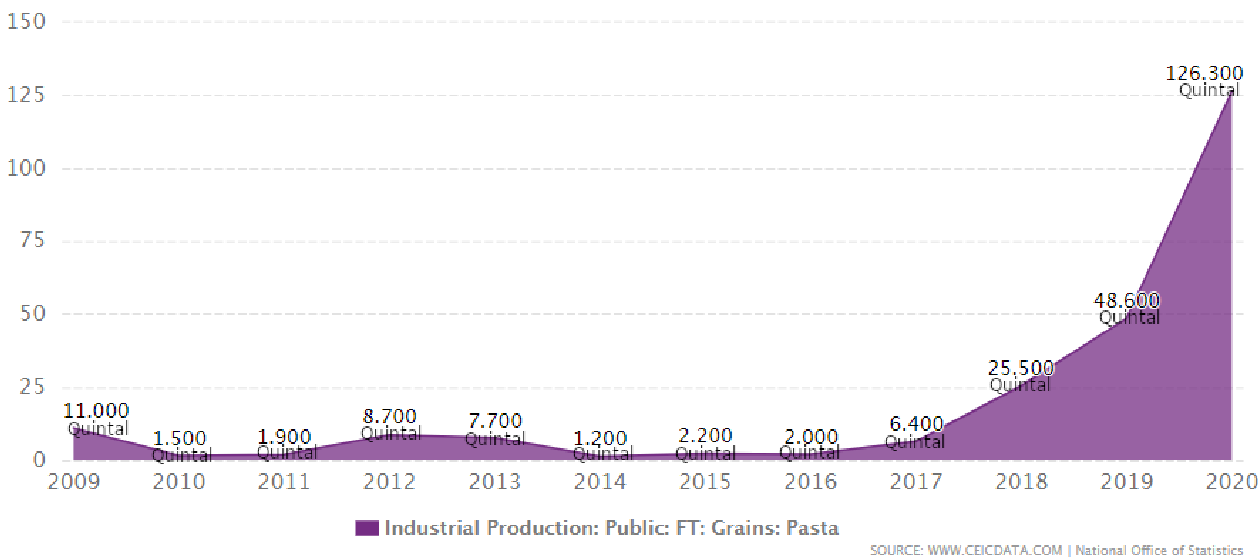

Figure 1 Production of pasta in Algeria from 2009 to 2020 (www.ceidata.com)

II.2 Production Process of Pasta

Production process of pasta involves several key steps (figure 4) **[2]:**

- **Ingredient Mixing:** Wheat flour, water, and optionally eggs are combined to form a dough. The ratio of ingredients may vary depending on the desired characteristics of the pasta.
- **Kneading:** The dough is kneaded to develop gluten network, which provides elasticity and structure to the pasta.
- **Shaping:** The kneaded dough is shaped into various forms, such as spaghetti, penne, or macaroni. This can be achieved using extrusion or rolling techniques.
- **Drying:** The shaped pasta is dried to reduce its moisture content, increase shelf life, and enhance its cooking properties. Drying methods can include air-drying or using temperature-controlled drying chambers**.**
- **Packaging:** Once the pasta has reached the desired moisture level, it is packaged and prepared for distribution and sale.

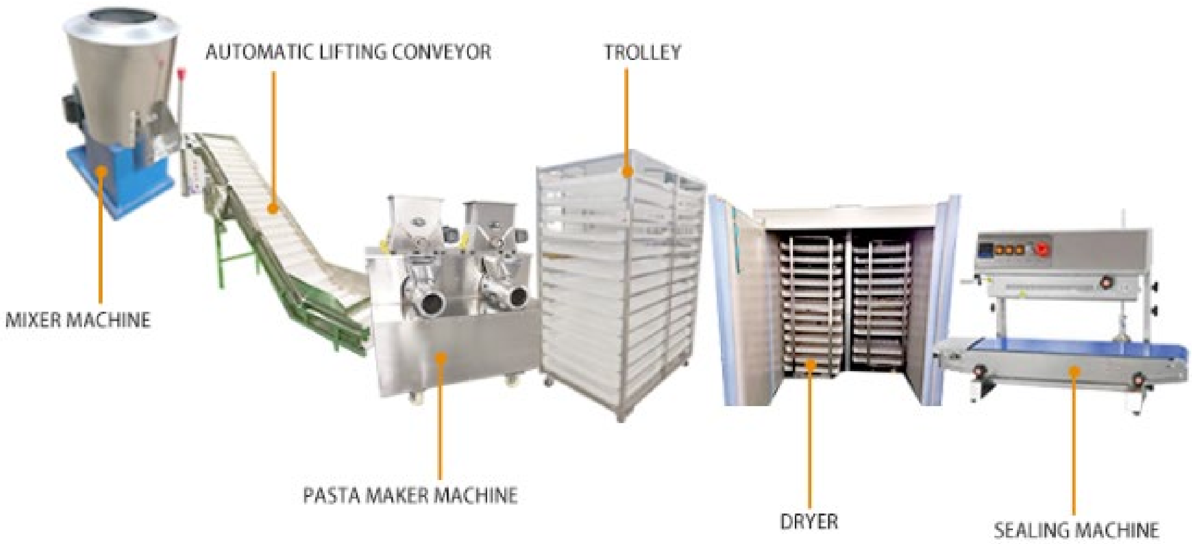

Figure 2 Image of a pasta production line layout (automaticfoodprocessingmachines.com)

II.3 Primary packaging types of pasta

packaging used for pasta can vary depending on the type of pasta, its intended use, and market preferences. Additionally, as the industry continues to focus on sustainability, there is an increasing adoption of eco-friendly packaging materials, such as compostable or biodegradable options, to reduce environmental impact but the primary packaging used in pasta typically includes the following options **[3]**:

- **Pasta boxes or cartons**
- **Plastic bags or pouches.**
- **Plastic containers.**
- **Vacuum-sealed packaging**.

II.4 Secondary pasta packaging

Secondary pasta packaging refers to the additional layer of packaging that is used to protect and contain pasta products after they have been packaged in their primary packaging, such as bags or pouches. It plays a crucial role in ensuring the integrity, freshness, and visual appeal of the pasta during storage, transportation, and display. Its commonly made out of corrugated cardboard.

II.5 Tertiary packaging of pasta

Tertiary packaging refers to the outermost layer of packaging that is used to transport and store multiple units of secondary packaged products. It is designed to provide additional protection, facilitate handling, and optimize efficiency in the logistics and distribution process. Its commonly made out of corrugated cardboard.

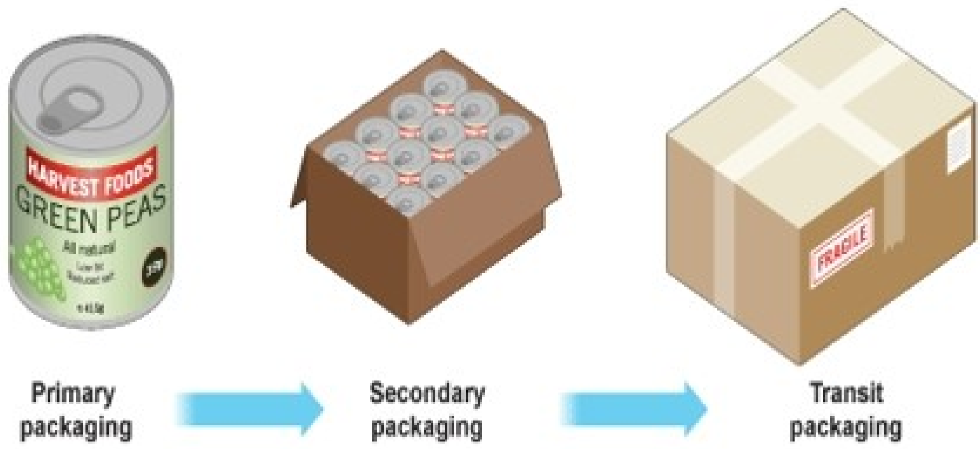

Figure 3 Different packaging layers

III General information about packaging

III.1 Definition of Packaging

Packaging refers to an item that serves the purpose of containing and safeguarding goods, enabling their handling and transportation from the producer to the consumer or user. Additionally, packaging plays a vital role in presenting products effectively, facilitating sales, and serving as a means of indirect communication between manufacturers and their customers **[4].**

III.2 Brief history on packaging

Throughout history, packaging has been essential for human travel and trade. In ancient times, people used animal skins, shells, and leaves for packaging. Ceramics and baskets were introduced around 6000 BC, while Egyptians pioneered glass containers by 1500 BC.

The Gauls invented barrels, and the Romans utilized clay amphorae. The concept of branded packaging emerged in England in 1866.

Until the late 19th century, natural materials like wood, cork, leather, and fibers were predominantly used.

In 1795, Nicolas Appert developed the appertization process for preserving food in sealed containers, which led to the advent of canned goods.

The 20th century saw the rise of plastics, offering lightweight, durable, and versatile packaging options such as polyethylene bags, polystyrene trays, and plastic bottles, which are still used to this day (figure 4) **[5].**

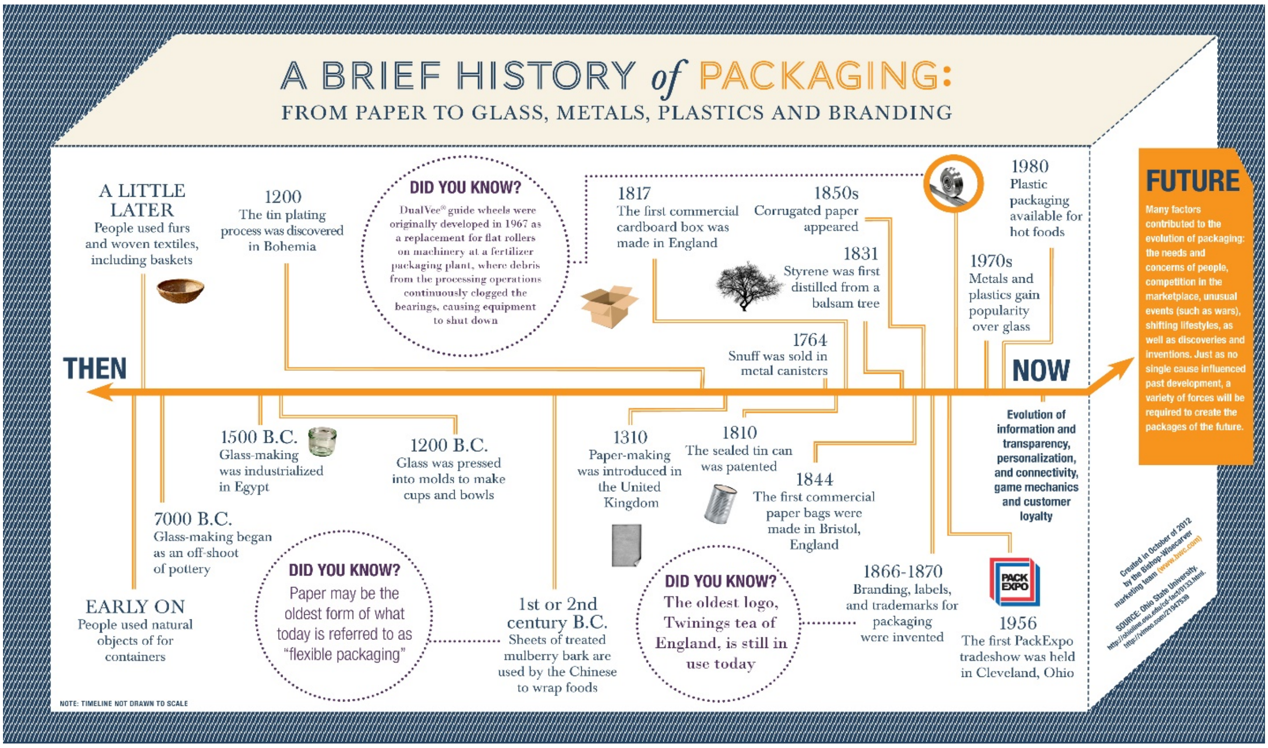

Figure 4 Brief history of food packaging
(structuralgraphics.com)

III.3 Functions of packaging

There are a few functions that product:

- **Protection:** One of the primary functions of packaging is to protect products from damage during handling, transportation, and storage. It acts as a physical barrier against impact, vibration, compression, and other external forces that could potentially harm the product. Packaging materials, such as corrugated cardboard, foam inserts, or bubble wrap, provide cushioning and shock absorption to safeguard fragile items,
- **Transport:** Packaging facilitates the safe and efficient transportation of products from manufacturers to distributors, retailers, and consumers. It ensures that products are properly contained, secured, and labelled for easy identification and handling. Packaging designs consider factors such as stack-ability, palletization, and weight distribution to optimize logistics and reduce the risk of damage during transit.
- **Communication:** Packaging serves as a communication tool by conveying important information to consumers. This includes product details, usage instructions, ingredients, nutritional information, safety warnings, and expiration dates. Effective labelling and graphic design on the packaging can enhance brand awareness, product differentiation, and consumer engagement.

- **Promotion:** Packaging plays a vital role in marketing and promoting products. It serves as a platform to display brand identity, logos, and product imagery, influencing consumer perception and purchase decisions. Eye-catching packaging designs, innovative shapes, and attractive visuals can help products stand out on store shelves and capture consumer attention.
- **Ease of Use:** Packaging is designed to enhance the user experience and provide convenience in product handling, opening, and resealing. User-friendly features, such as easy-to-open seals, tear strips, re-sealable closures, or portion-controlled packaging, make products more accessible and convenient for consumers.
- **Defense:** Packaging can provide a level of security and tamper resistance for products. Seals, shrink-wraps, or anti-counterfeiting measures help protect products from tampering, ensuring their integrity and safety. This is especially crucial for pharmaceuticals, food, and other sensitive goods where product safety is paramount.
- **Preservation:** Packaging helps preserve the quality and freshness of products, particularly perishable items like food and beverages. It employs techniques such as barrier films, vacuum sealing, or modified atmosphere packaging to extend the shelf life of products, maintain their flavor, and prevent spoilage caused by exposure to air, moisture, or light.
- **containment:** it's the primary function of packaging, it helps contain and safeguard items against the outside world.

These functions work together to ensure that products are well protected, effectively transported, communicate relevant information to consumers, promote brand visibility, provide convenience, maintain product quality, and enhance overall consumer satisfaction **[6].**

III.3.a Content-Container Interactions

There are various material transfers that can occur in the food/packaging system due to physicochemical mechanisms such as:

- **Permeation:** Packaging materials allow gases or liquids to pass through their structure, potentially affecting the quality and composition of the packaged product. This can involve the movement of substances like oxygen, moisture, or aroma compounds across the packaging barriers.

- **Sorption:** Packaging materials have the ability to absorb or adsorb substances from the surrounding environment or the packaged contents. This can include the retention of moisture, oils, flavors, or other components by the packaging, which may impact the properties and stability of both the packaging and the product.
- **Migration:** Chemicals, additives, or contaminants present in the packaging material can migrate into the packaged product or vice versa. This transfer of substances can occur due to factors such as temperature, contact time, or the chemical compatibility between the packaging and the contents. (Figure 5) **[7].**

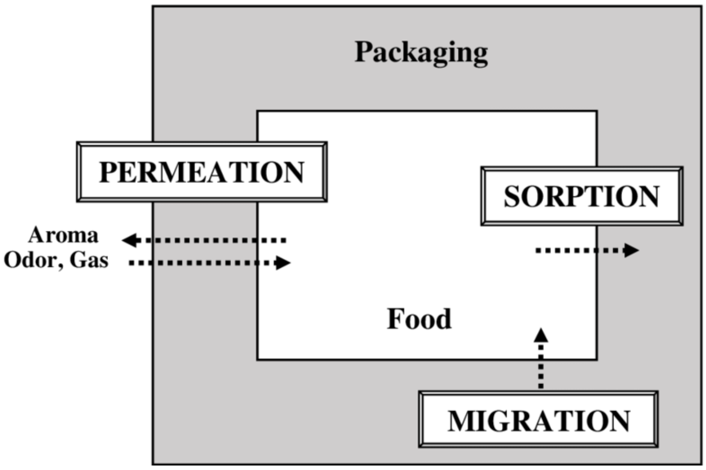

Figure 5 Diagram showing container-content interactions

IV Corrugated Cardboard Packaging and Raw Materials Used at Maghreb Emballage

IV.1 Corrugated Cardboard

Production of corrugated cardboard reaches millions of tons annually globally (figure 6). The use of this material for packaging purposes is also widespread due to the advantages it offers throughout the logistics chain, from raw material sourcing to the end consumer, and its environmental benefits, such as:

- Ease of delivery (flat delivery).
- Manual assembly when needed.
- Its use in packaging allows for protection, preservation, transportation, handling, information provision, and convenience of use.
- A biodegradable and recyclable material.

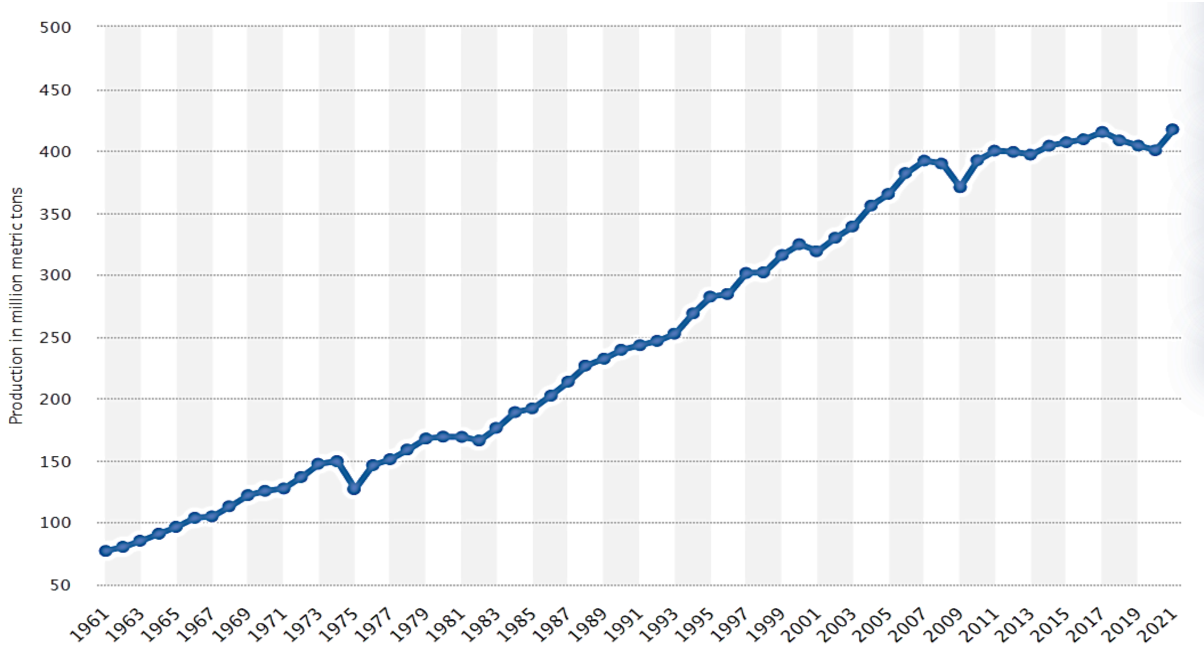

Figure 6 Global Production of cardboard from 1961 to 2021 (Statista.com)

IV.1.a Definition of Corrugated Cardboard

Corrugated cardboard is composed of two words: "cardboard," its constituent element, and "corrugated," which refers to the characteristic of the cardboard. Corrugated cardboard packaging is a volume constructed from a flat, rigid board consisting of one or more layers of fluted paper glued between one or more cardboard sheets. Its shape and performance are tailored to the product being packaged.

The cardboard sheet is the fundamental element for creating the packaging. Corrugated cardboard is obtained through thermomechanical deformation of a flat strip**,** resulting in the well-known corrugations, which are fixed with starch-based glue between two cover sheets (figure 7). Its designation varies depending on the number of layers. (Figure 8, 9,10):

The first documented use of corrugated cardboard dates back to the mid-19th century. In 1856, English merchant and inventor Sir Henry Cole commissioned the production of a corrugated paper for packaging purposes. However, it wasn't until 1871 that the patent for corrugated cardboard was issued to Albert Jones, an American printer and packaging manufacturer **[8, 9].**

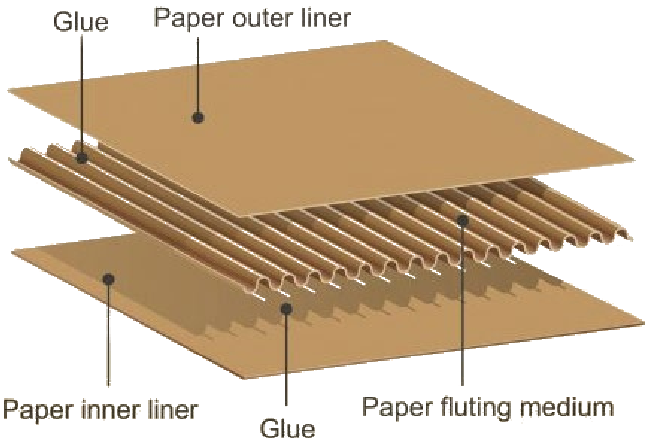

Figure 8 Double face cardboard panel composition.

Figure 7 Double-double-face corrugated cardboard panel.

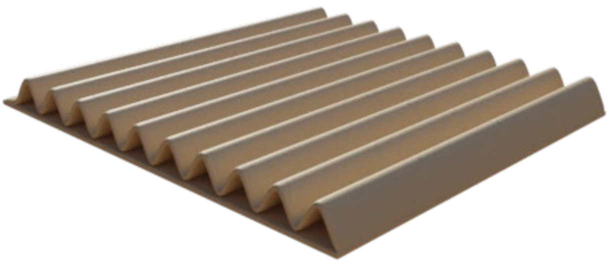

Figure 10 Simple-face corrugated cardboard panel.

Figure 9 Double-Face corrugated cardboard panel.

IV.1.b Types and profiles of corrugations:

Table I Types and profiles of corrugations

Profile	Type	Height(mm)	Wavelength (mm)	Number of folds (f/m)	Coefficient of waviness
Big Profile	A	4.0 – 4.8	8.0 – 9.5	105 – 125	1.48 – 1.53
Small profile	B	2.2 – 3.0	5.5 – 8.5	153 – 181	1.28 – 1.43
Medium Profile	C	3.2 – 4.0	6.8 – 8.0	125 – 147	1.42 – 1.50
Micro-Profile	E	1.0 – 1.8	3.0 – 3.5	285 – 334	1.22 – 1.29

IV.2 Paper

IV.2.a Definition of Paper

Paper is a material made from plant-based cellulose fibers. It is considered a fundamental material in the fields of writing, drawing, printing, packaging, and painting. It is also used in the production of various components, such as corrugated cardboard **[10].**

Paper is the raw material used for manufacturing corrugated cardboard. It is stored in the company in the form of different Rolls (figure 11) and each roll has a technical specification sheet that includes the following information (figure 12):

- Grammage (g/m²)
- Weight (Kg)
- Width (mm)
- Roll number
- Supplier's name

Figure 11 Storage of cardboard paper spools.

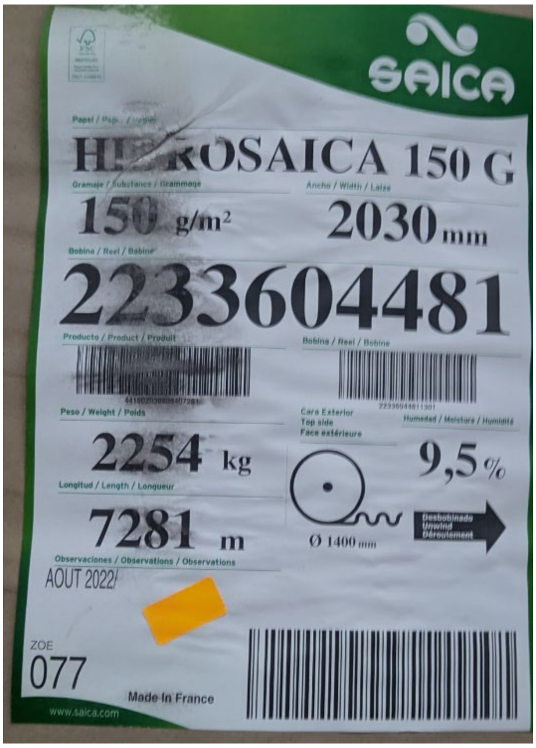

Figure 12 Technical specification sheet of HidroSaica 150 G paper.

IV.2.b Some paper spool Types, their grammage and their use case

Table II Some paper spool Types, their grammage and their usage case

Paper Type	Grammage (g/m^2)	Usage
DuoSaica	From 75 to 280	Cover and fluting paper
HidroPlus Saica	From 140 to 190	Fluting paper for corrugation
SaiKraft	From 115 to 200	External and internal cover paper
White Top Test Liner C	120	External cover paper
Nature Kraft	From 115 to 245	Internal and external cover paper

IV.3 Glue

Glue used is a liquid, gelatinous, or pasty substance used to bond pieces together. In the packaging industry, it is preferable to use non-synthetic raw materials, which is why manufacturers prefer to choose starch-based glue. This type of glue is a biological product, making it more effective and compliant with hygiene standards, especially for manufacturing processes intended for the food industry **[11].**

IV.3.a Starch based Glue Composition

According to the « stein-hall » procedure:

- 78% water: allows the starch grains to hydrate during gelatinization under the influence of heat, also enhances adhesive power.
- 21% starch: viscosity is adjusted by the amount of starch.
- 0.6% soda ash: prepares the substrate and lowers the gelatinization temperature of the starch. It also facilitates penetration into the paper due to its wetting properties.
- 0.4% borax: increases initial viscosity and contributes to bonding during the gelatinization of secondary starch.
- Protective agent: such as formaldehyde, which protects the glue from fermentation.

These materials are carefully selected and used in specific formulations to ensure optimal bonding, strength, and other desired properties in the production of cardboard panels **[12].**

IV.4 Ink

IV.4.a Definition

Ink is a liquid or viscous substance containing pigments, used for writing, printing, and drawing purposes **[13].**

IV.4.b Composition of inks used in corrugated cardboard printing

Composition of ink depends on the printing technique, the type of printer, and the physical nature of the substrate being printed on. In the case of corrugated cardboard printing, the technique used is flexographic printing. The type of ink used is referred to as liquid ink, with low viscosity (approximately 10 to 100(mPa/s)). These inks contain a high proportion of solvents, allowing for fast drying, primarily through physical means (heat),

An ink is composed of several components, including:

- Varnish: Varnish is the primary component of ink, representing 70% of the total composition. There are two types of varnishes used:
  - Technological varnish (opaque), used for selective application.
  - Transparent varnish, used for overprinting.
- Pigment: The pigment in ink is responsible for creating the desired colored image. Pigments make up 30% of the ink composition.

- Solvent (water): Water is used in inks specifically designed for flexographic printing. The boiling temperature of the solvent influences the ink drying process**.**

At ME, the base colors used in ink include white, yellow, magenta, cyan, orange, green, vermillion (red), pink, violet, and black, which adhere to **PANTONE** specifications [**14].**

IV.5 Production and transformation of cardboard packaging

IV.5.a Production

Production of corrugated cardboard panels involves a multi-step process that transforms raw materials into a versatile packaging material widely used across various industries. Corrugated cardboard consists of three layers: two flat outer layers known as linerboard and a wavy inner layer called fluting. The combination of these layers provides strength, rigidity, and cushioning properties to the final product**.**

IV.5.b Transformation

Transformation of corrugated cardboard panels involves converting the flat panels into functional packaging solutions. This process includes various steps that shape, cut, fold, and join the panels to create customized packaging products according to specific requirements set by the client **[15].**

IV.6 Quality control and risk assessment during production

IV.6.a Quality control

This refers to the processes and activities carried out to ensure that products or services meet specified quality requirements. It involves inspecting, testing, and monitoring various stages of production to identify and address any deviations or defects. By implementing quality control measures, companies can uphold consistent product quality, meet customer expectations, and safeguard their brand reputation.

IV.6.b Risk assessment

This on the other hand, involves identifying, analyzing, and evaluating potential risks that may affect the quality or safety of products or services. It aims to proactively assess and mitigate risks to prevent quality issues, product failures, or safety incidents. Through risk assessment, companies can anticipate and address potential risks, ensuring the delivery of safe and reliable products while protecting the well-being of customers especially when it comes to packaging used in the food industry **[15].**

MATERIALS AND METHODS

V Production of secondary pasta packaging

In our case the client has provided us with a sample that has been manufactured by another manufacturer on how the final product should look like which is based on a Regular Slotted Container (RSC) design with a loaded weight of 6Kg (figure 13).

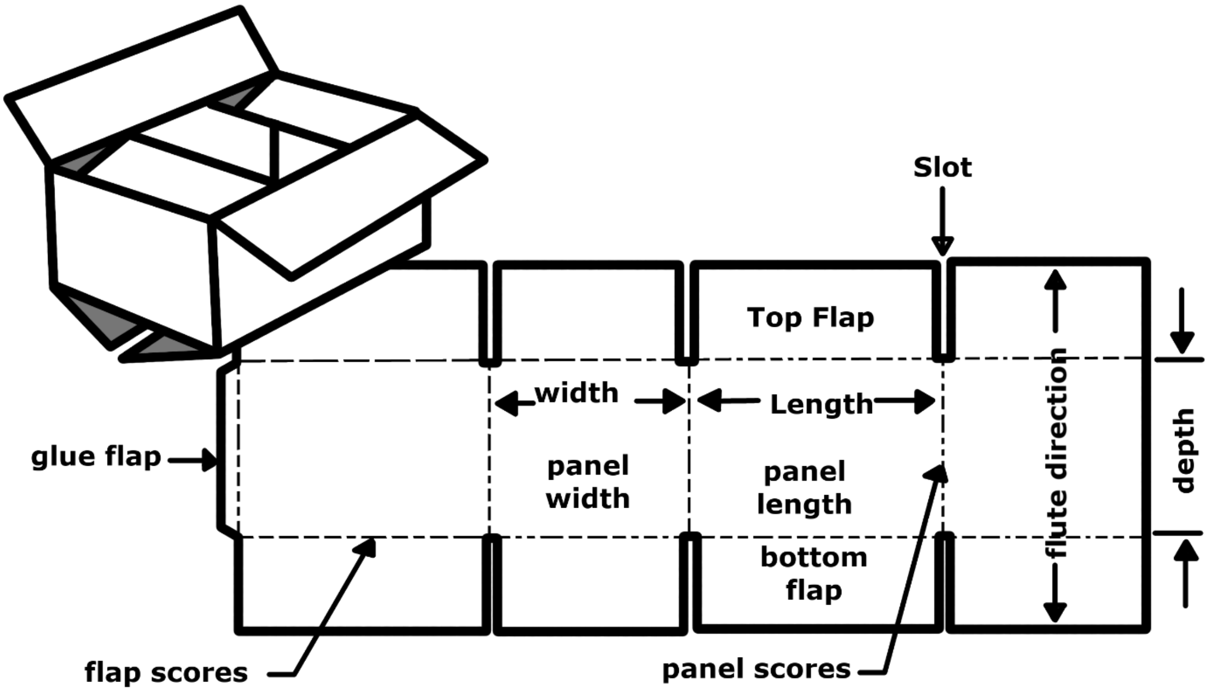

Figure 13 Regular Slotted Container (RSC) design layout

V.1 Sample composition tests

The sample composition tests are conducted on the sample provided by the client, it is important to note that these testes were done inside a temperature and humidity-controlled environment of 24°C ±2 and humidity of 50% ±5% respectively **[15].**

V.1.a Apparatus

- **Circular cutting knife:** Used to cut disk-shaped cardboard samples from the original sample, with a surface area of 100 cm^2 (Figure 17).
- **Micrometer:** A tool used to determine the thickness of the sample and the paper used (Figure 14).
- **Digital scale:** Used to weigh the cut samples as well as the separated papers (Figure 15).
- **Roller:** A heavy metal tool used to flatten the paper after it has been placed in the absorbing paper.
- **Laser measuring tool:** Used to measure the dimensions of the box.
- **BCT testing machine:** (short for Box Crush Test) used to test vertical compression of the box (Figure 16).

V.1.b Method of operation of the Sample composition tests

1. Using the laser measuring tool, to measure the width, height, and depth of the sample from the inside
2. Using the digital scale, to weigh the entire sample and record the value in the computer.
3. Using the BCT machine, we measure the BCT value in N of the box and record that in the computer.
4. Using the circular cutting knife, to cut two samples from the original sample.
5. Submerge one of the samples in the large distilled water container for approximately 10-15 minutes to weaken the starch-based glue.
6. Weigh the other sample on the digital scale and record the value in the computer. Set this sample aside for safekeeping.
7. Remove the submerged sample from the water and shake it to fully separate the layers, ensuring any residual glue is removed.
8. Sandwich the separated layers between absorbing paper and use the roller to flatten the paper, maximizing contact between the absorbent paper and the cut samples.
9. After 24 hours, weigh the cut and dried samples using the digital scale.
10. Use the micrometer to measure the thickness of the sample and the separated layers and record their value on the computer.
11. Record the weight and thickness values in the computer database, which is shared across the entire company **[16].**

Figure 15 Image of a L&W Micrometer.

Figure 14 Image of a Lab Scale.

Figure 17 Image of a Circular Cutting knife

Figure 16 Image of a BCT testing machine.

- **Stacking Determination** To calculate the number of stacked boxes, the following formula is applied (figure 18):

$$Nl = \frac{BCTp}{Pc \times G \times Coef}$$

Nl: Number of layers

BCTp (N): vertical compression resistance of the box.

Pc (Kg): weight of the box loaded.

G: gravity (10 N).

Coefp: product coefficient:

- 1 for load-bearing product,
- 2.5 for semi-load-bearing product,
- 3 for non-load-bearing product

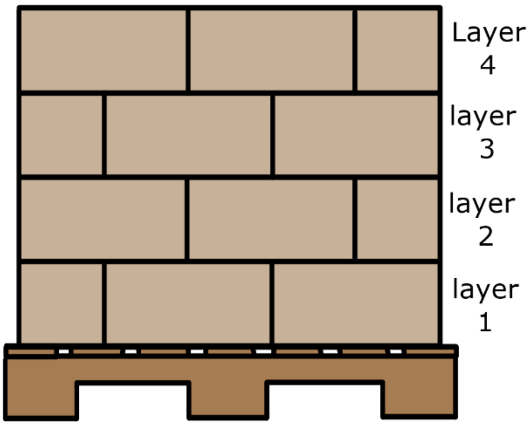

Figure 18 Stacking boxes in layers on the pallet

V.1.c Goal of these tests

These tests allow us to determine the paper used, its grammage, packaging dimensions in the sample provided by the client in order to replicate it **[15].**

V.2 Formulation of a product document "EMB"

After conducting the composition tests, the next crucial step is to collaborate closely with the client to define the specifications for the production process. This involves making a proposed sample that uses as close of materials of the original sample as possible using premade stored cardboard sheets, and cutting them to the client's specs using a device called a Slotter, and doing some tests to compare to the original sample. After final validation with the client, comes determining the desired quantity of boxes to be produced, identifying the specific machine to be used for production, finalizing the design and details, and addressing any other specific requirements or preferences from the client, all of these specifications and data is then put into a database that's indexed by what's called internally as an **EMB number (Ex: EMB-210513) [15].**

V.3 Production of cardboard panels

At ME, they have two corrugators, and the technical process is almost the same for each machine, the only difference is age, one is new the other is old, they are both made by the same company called BHS corrugated (attachment 5). these corrugators are composed of two parts (see the figure 19 below):

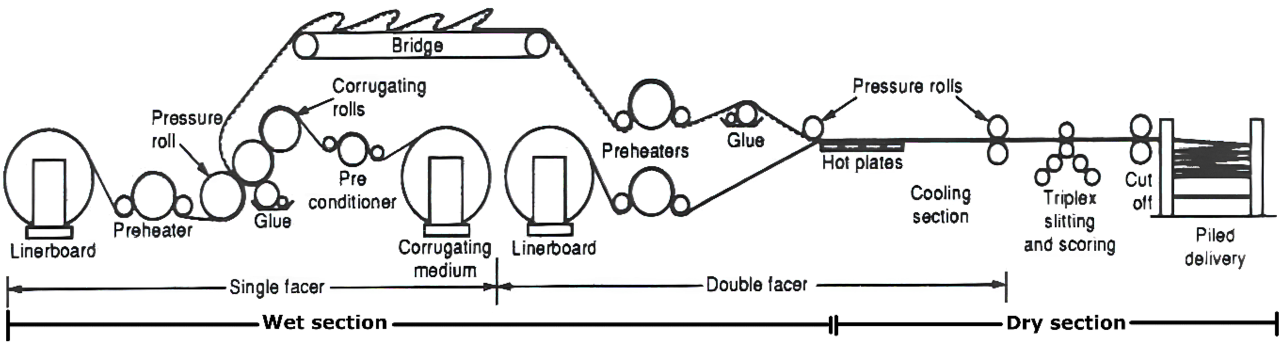

Figure 19 Simple diagram of a corrugation machine.

- **Wet section (figures 20 and 21)**

This section includes the following steps/operations:

1. Corrugation of the paper.
2. Gluing of the inner liner and corrugated medium to form what is called single-face board.
3. Gluing of the single-face board with the outer liner to form what is called double-face board **[17].**

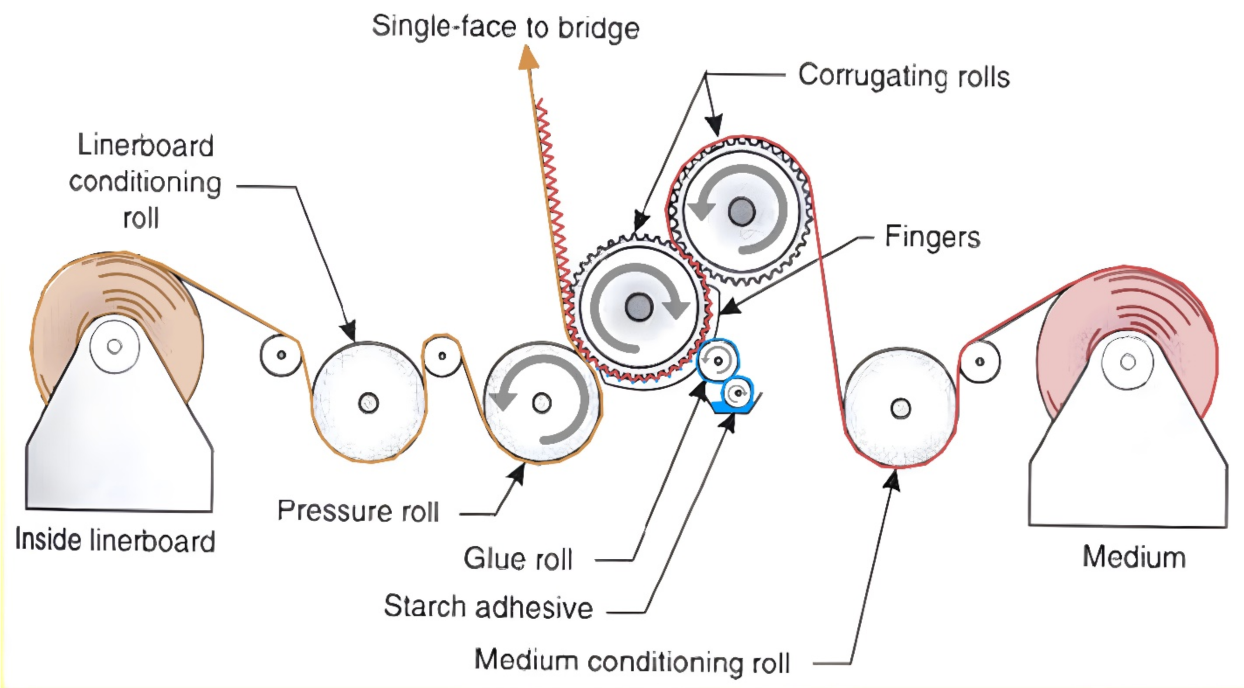

Figure 20 Simple diagram of the single facer in the wet section of the corrugation machine.

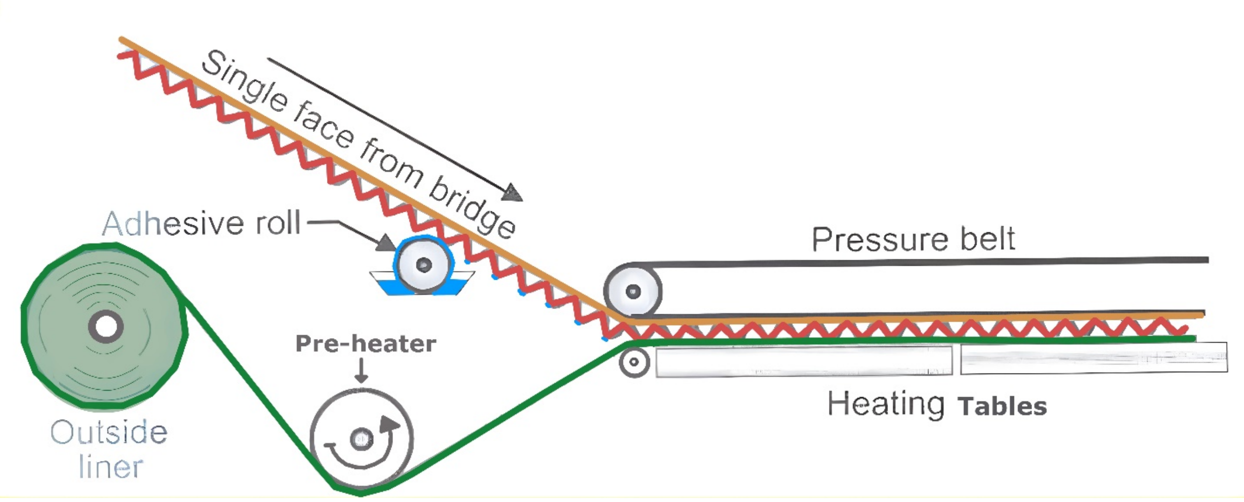

Figure 21 Simple diagram of the double facer in the wet section of the corrugation machine.

- **Dry section (figure 22)**

In this part, the corrugated boards are cut into 3m x 1m sheets **[17].**

The product then proceeds to the receiving area, awaiting further processing.

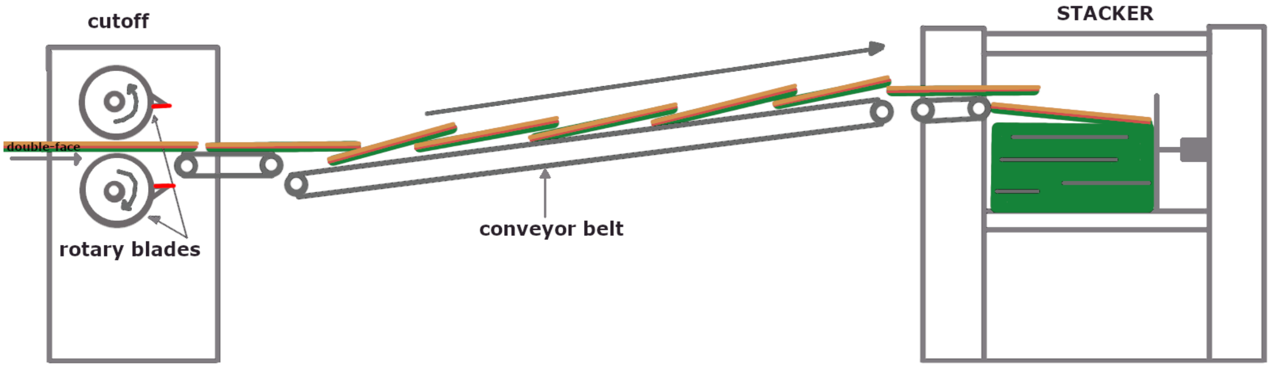

Figure 22 Simple diagram of the dry section of the corrugation machine.

V.4 Transformation of cardboard panels

At the output of the corrugator machine, we obtain cut cardboard sheets ready for transformation, so, in order to get our final product, it has to go through a few more machines. **[15]**

V.4.a Apparatus

This is all done using one single machine called the BOBST 820tm (figure 23) which does all the cutting, felxo-printing and folding in one package. This machine is operated by 4 people, one operator handling the control panel, 1 staff handling all ink related things and 2 other people loading the cardboard panels into the machine.

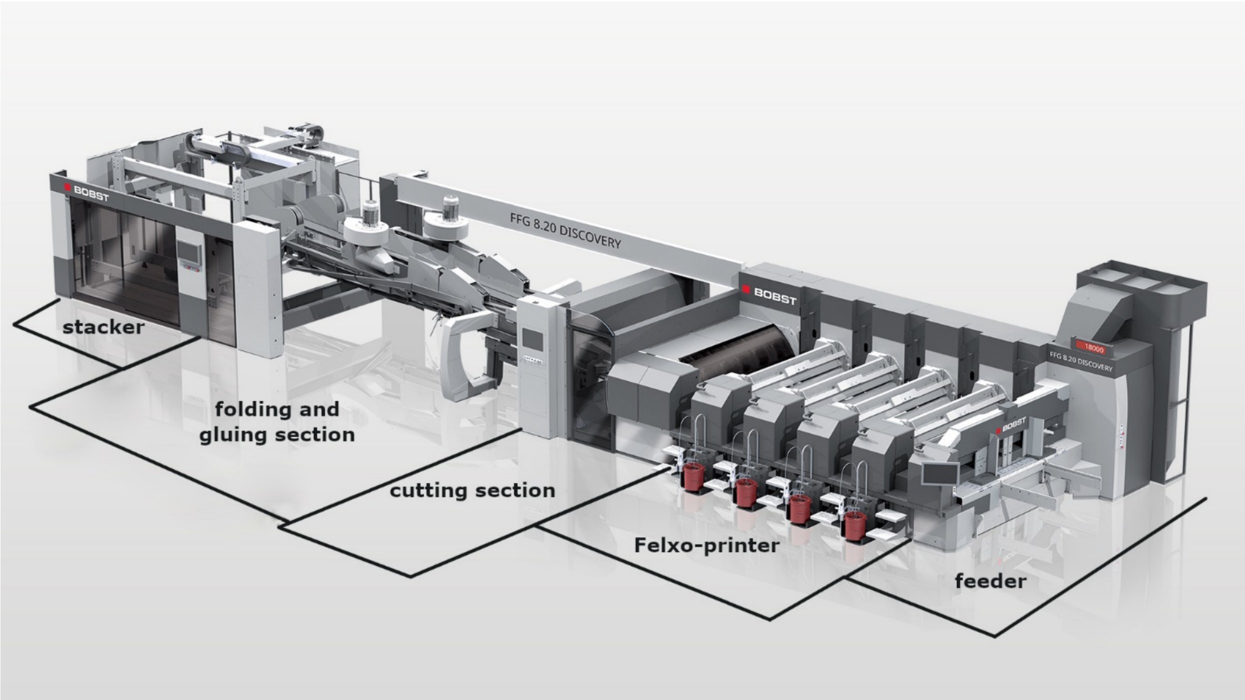

Figure 23 BOBST 820 and its transformation sections (BOOBST.COM).

V.4.b Method of operation

The operator begins by cleaning the printer section of the machine, ensuring a quick and automated process due to the water-based ink used. The ink solutions for the two colors, blue and yellow, are then loaded into their respective printer sections, along with the corresponding printing plates. Concurrently, the rotary cutting mold is loaded into the cutting section of the machine.

Next, the cardboard panels are carefully loaded into the feeder, with the printing (white side) side facing downward. The machine picks up the panels and transfers them to the printing section, where the design is printed onto them using a technique called flexography (figure 26). From there, the panels move into the cutting section, where the cutting mold precisely cuts them into their final shape. Any excess paper that is cut away is collected under the machine and sent for recycling (figure 2).

The boxes, now printed and cut, proceed to the folding and gluing section of the machine. Here, they are folded and securely glued shut using polyvinyl acetate-based glue known for its fast-drying properties. This ensures the boxes maintain their shape and remain sealed.

After preparing the machine, the operator initiates production by running a sample batch. Typically, 6-10 samples are made, with the first 3 being discarded for recycling due to the nature of the printing process as the first few prints have washed out colors and lines from cleaning the printing plates. The remaining sample is carefully examined. The operator pays close attention to various aspects, including printing quality, print alignment using the CMYK alignment crosshair (figure 24)**,** cutting quality, proper box closure, and the strength of the glue to ensure the box remains securely closed.

Based on the examination, adjustments are made if necessary, and another sample is produced. The compliance of this new sample is checked to ensure it meets the specifications and closely resembles the client's provided sample. If the produced sample meets the desired criteria, both in terms of quality and accuracy, the production process commences at full capacity.

Throughout the production process, the operator maintains vigilance, making periodic inspections to ensure consistent quality and troubleshoot any issues that may arise. By following this meticulous method of operation and conducting thorough quality checks, the production of high-quality cardboard boxes is ensured, meeting the requirements and expectations of the client. **[17].**

Figure 24 CMYK color alignment croshair

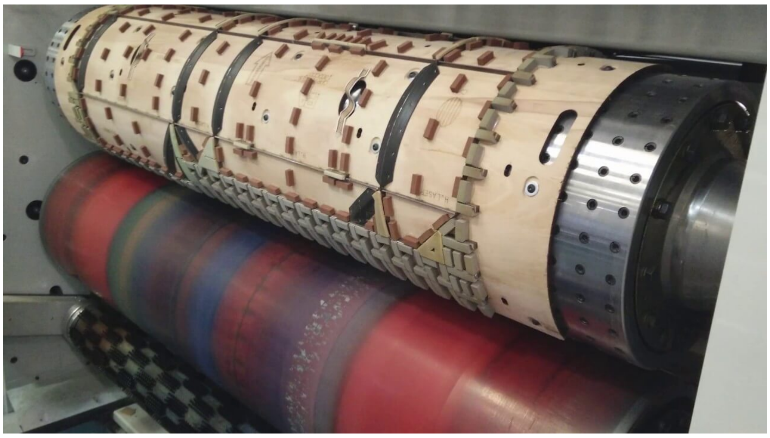

Figure 25 Rotary cutting mold.

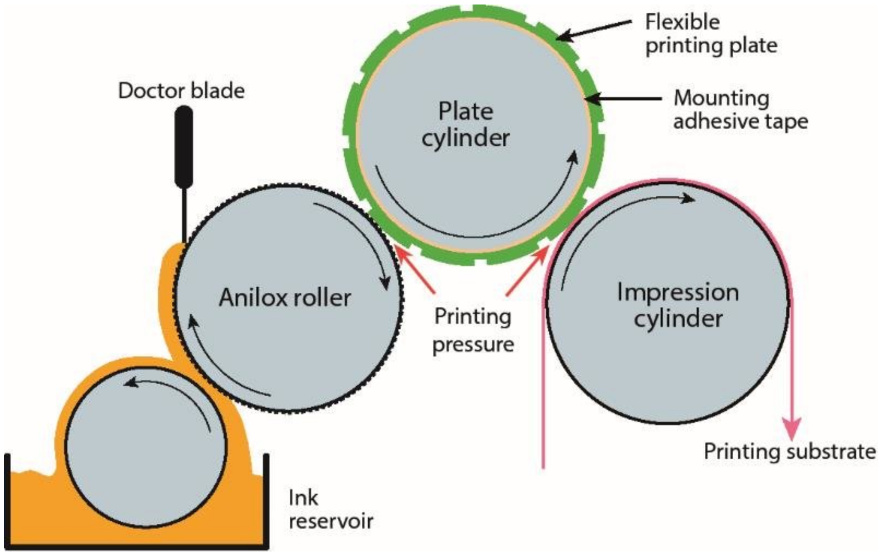

Figure 26 Simplified diagram of the printing process using flexography

V.5 Quality tests conducted during production of carboard panels

V.5.a Method of operation

1. **During production of cardboard panels**

- **Visual checks of the paper reels:** quality control agent checks the reels that are going to be used in the production for any damage from the storage or transport.
- **flow cup viscosity test of the glue**: Glue containers are checked every 2 hours using of the production run, using a stein hall flow cup viscometer, where the operator fills the cup and starts a timer as soon as the top indicator is visible, then stops it as the bottom one shows, the time it took for the glue to drip out is then written down and using a stein hall viscosity cup (figure 27 below) **[15].**

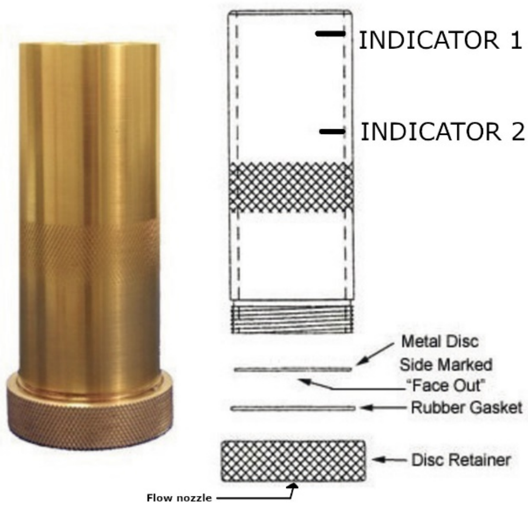

Figure 27 Stain Hall Viscusity cup and its diagram

- **Visual checks on the final cut and creased panels:** this is done by the operator that's responsible of manually packing the panels onto pallets for intermediate storage, he checks for the quality of the cuts if there are no tears, he also checks if the glue that holds the layers is cured by trying and separating the layers on one sample randomly picked, and if there is no Washboarding, or the panels come out curved (figure 28).

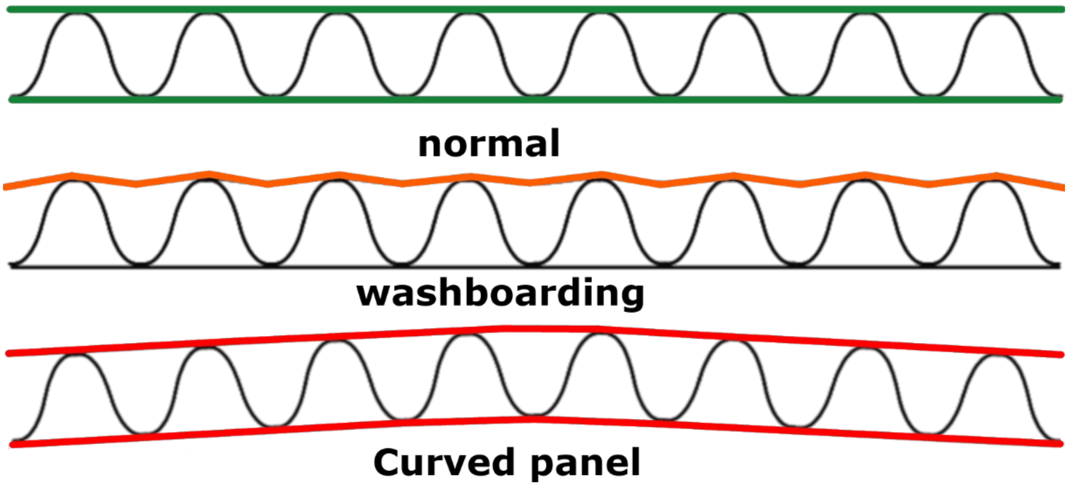

Figure 28 Different phenomenon's that can occur during production of cardboard panels.

2. During transformation of cardboard panels

- **Print alignment and quality:** this is checked by the control agent during production by measuring pointers printed on the box itself and checking their alignment
- **Color quality:** this is checked to ensure printed color is as close to the sample provided as possible.
- **Closed Box shape:** this is done by both the operator and the quality control agent to ensure that the boxes are shaped correctly and close correctly when they arrive to the client.
- **Glue position and strength:** check if the glue is not seeping from the gluing flap, and test if the glue is holding by tearing the glued flap open.
- **Cuts and creases quality:** the quality control agent checks if the cuts are clean and there is no residue left attached, and the creases are not cracked, if anything is wrong the agent notifies the operator to make adjustments, if the problem persists the production gets halted.

3. BCT Test (figure 29)

using the BCT machine, we do this test on 3 samples picked from the end of the production line every 1-2 hours of the production run, these values then get compared to the other values measured before of the same box design using its EMB, if new values are higher or lower than the average by considerable value, the quality control agent notifies the operator to stop production and an investigation is started on the cause. This BCT value is measured in N/cm^2.

- **Test Objective:** It aims to measure the stacking behavior of the box in different usage scenarios.
- **Theoretical formula for calculating BCT (Vertical Compression Resistance)**

$$\boldsymbol{BCT} = \mathbf{5.3} \times \boldsymbol{ECT} \times \sqrt{(\boldsymbol{L} + \boldsymbol{l}) \times \boldsymbol{h} \times \boldsymbol{G}} - (\mathbf{15\%} \times (\mathbf{5.3} \times \boldsymbol{ECT} \times \sqrt{(\boldsymbol{L} + \boldsymbol{l}) \times \boldsymbol{h} \times \boldsymbol{G}}$$

L(cm)**:** length of the box.

l(cm)**:** width of the box.

H(cm): height of the box.

ECT(KN/m^2)**:** Edge crush Test Value.

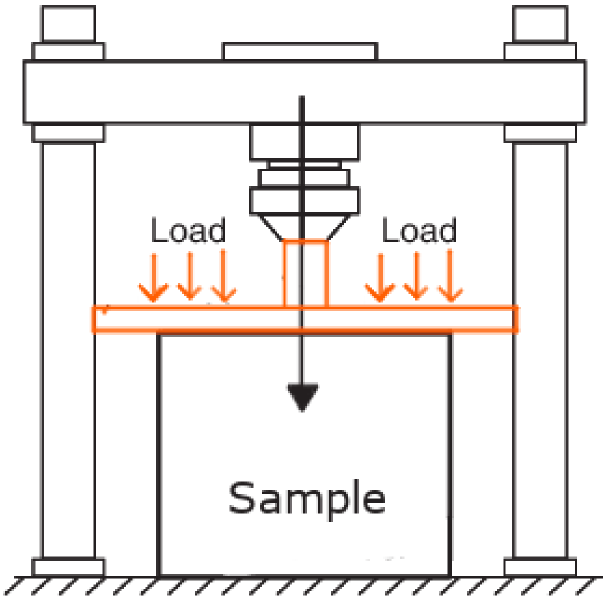

Figure 29 Simple diagram of the BCT test

V.5.b Goal of these tests

These tests are conducted to ensure the quality and integrity of the final cardboard panels. By subjecting the panels to various tests and inspections, any potential flaws, defects, or deviations from the desired specifications can be identified and addressed. These quality tests play a crucial role in maintaining the standards and performance of the panels, ensuring that they meet the required strength, durability, dimensional accuracy, and visual appearance. Additionally, these tests also help in assessing the adherence to industry regulations and standards, as well as meeting the specific requirements and expectations of the clients **[16].**

RESULTS AND DISCUSSION

VI Results

VI.1 Results from the composition tests

The composition characteristics were evaluated through the implementation of relevant tests, and the findings are consolidated in Table 3.

Table III Composition test results from both original sample and proposed sample.

origin	parameter	Original sample	Proposed Sample	difference	Standard Limits
Whole Box	**W(mm) x H (mm) x D (mm)**	352 x 159 x 279	352 x 159 x 278	0 x 0 x 1	±10
	Weight (g)	420.7	415.87	4.83	±10
	BCT(N)	2262.06	2099.38	162.68	±500
Cut sample ($100cm^2$)	**Weight (g/m^2)**	384.5	371.15	13.35	±50
	Thickness (µm)	3770.4	3840.6	70.2	±500
	Flute Type	C Flute	C Flute	//	//
External Liner	**Weight (g/m^2)**	121.11	BLS 120 **(Attachment 2)**	1.11	±10
Flute	**Weight (g/m^2)**	132.73	HS 130 **(Attachment 3)**	2.73	±10
Internal Liner	**Weight (g/m^2)**	130.61	DS 120 **(Attachment 4)**	10.61	±10

In the case of the whole box:

The dimensions of the proposed sample are slightly smaller in height, with a difference of 1mm compared to the original sample.

The weight of the proposed sample is slightly lower, with a difference of 4.83g compared to the original sample.

The BCT (Vertical Compression Resistance) value of the proposed sample is lower, with a difference of 162.68 N compared to the original sample.

In the case of the cut sample:

The weight per square meter of the proposed sample is slightly lower, with a difference of 13.35g/m2 compared to the original sample.

The thickness of the proposed sample is slightly higher, with a difference of 70.2µm compared to the original sample.

Both the original and proposed samples have C Flute as the flute type.

In the case of the external liner:

The weight per square meter of the proposed sample is slightly lower, with a difference of 1.11g/m2 compared to the original sample.

In the case of the Flute:

The weight per square meter of the proposed sample is slightly lower, with a difference of 2.73g/m2 compared to the original sample.

In the case of the internal liner:

The weight per square meter of the proposed sample is slightly lower, with a difference of 10.61g/m2 compared to the original sample.

VI.1.a Conclusion

Based on the provided values and standard limits, the following conclusions can be drawn:

Whole Box dimensions: The proposed sample shows a slight difference in the depth (D) dimension, with a decrease of 1 mm compared to the original sample.

This difference falls within the acceptable range of ±100 mm.

Weight: The proposed sample has a weight of 415.87 g, which is 4.83 g lower than the original sample.

This difference is within the standard limit of ±10 g.

BCT: The proposed sample has a BCT value of 2099.38 N, which is 162.68 N lower than the original sample.

This difference falls within the standard limit of ±500 N.

Cut sample: The proposed sample has a weight of 371.15 g/m2, which is 13.35 g/m2 lower than the original sample.

This difference is within the standard limit of ±50 g/m2.

Thickness: The proposed sample has a thickness of 3840.6 µm, which is 70.2 µm higher than the original sample.

This difference falls within the standard limit of ±500 µm.

External Liner, Flute, and Internal Liner: The proposed sample's weights for these components are

within the range of ±10 g/m2, based on the values obtained from the paper datasheet (Attachments 2,3,4).

VI.2 Calculating stacking layer number and palletization during usage:

$$Nl = \frac{BCTp}{Pc \times G \times Coef} = \frac{2099.38}{6 \times 9.8 \times 2.5} = 14.29$$

BCTp (Box Crush Test of the Package): **2099.38N**(table III)

Pc (box weight loaded): **6Kg** (12 x 500g pasta plastic pouches, data is retrieved from the Product document)

G(gravity): **9.8N**

Coef: **2.5** (load bearing product) **[15].**

1. The case can support 14 Boxes above itself
2. Height of the box is 160mm meaning the container height is:

$$14 \times 160mm = 2240mm$$

VI.2.a Conclusion

From 1 and 2 it is concluded that the number of maximum layers that can be stacked on top before losing structural integrity of package is **14 layers with a maximum height of 2.240m.**

After informing the client of these values and findings the sample is **accepted by both the client and the commercial team** and it's decided that the quality cardboard panel that will be used based on the values of the proposed sample is:

120BLS – 130HS – 120DS

All of the paper used for this packaging is certified to be safely used in packaging that has direct contact with the contained item, even though we are making secondary packaging for pasta **[15, 17].**

VI.3 Results from the quality tests during production of cardboard panels

VI.3.a Paper spools visual checks

After the visual inspection tests concluded the findings are consolidated in table 4 below:

Table IV Results from the visual inspection of the spools before loading.

Spool	BLS 120				HS130				DS120			
Loading day	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Water / Humidity Damage	No	No	No	No	No	No	No	No	No	No	**Yes**	No
Transport / Handling Damage	No	No	No	No	No	**Yes**	No	No	No	No	No	No

We see that during day 1 and 4 when the spools were inspected before use, there was no sign of damage, but on day 2 the HS130 spool showed a deep tear but no water / humidity damage, then on day 3 we noticed that DS120 spool had some severe humidity damage and had to be replaced with an undamaged spool.

VI.3.b corrective measures

The water and humidity damage of the spools could be mitigated by controlling the temperature and humidity in the storage area by installing humidifiers and heating/ cooling apparatuses.

VI.4 Flow cup viscosity

the results from the viscosity tests conducted during production are marked in the table V below:

Table V Glue viscosity each day using a flow cup during the 4 days of panel production

	Flow cup drain time (s)															
Day	**1**				**2**				**3**				**4**			
Test number	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**
Container 1	125	124	122	124	130	129	128	124	128	117	128	118	121	120	125	121
Container 2	128	126	125	123	132	121	123	121	125	119	128	115	128	127	126	118

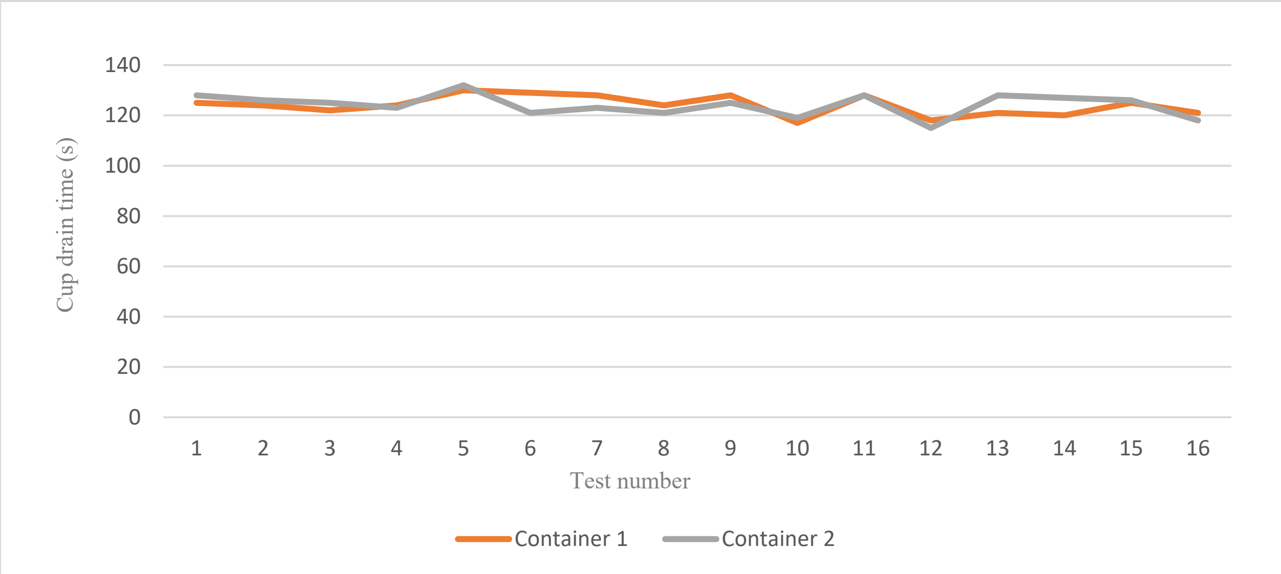

Figure 30 graph showing the flow cup drain time on each conducted test for both glue containers.

Based on the provided data, the flow cup drain time was measured for multiple tests conducted on different days we can see that on:

Day 1: Container 1: The values range from 122 to 125. There is a moderate variation within this range, Container 2: The values range from 123 to 128. There is a relatively small variation within this range.

Day 2: Container 1: The values range from 124 to 130. There is a relatively small variation within this range, Container 2: The values range from 121 to 132. There is a relatively small variation within this range.

Day 3: Container 1: The values range from 117 to 128. There is a relatively small variation within this range, Container 2: The values range from 115 to 128. There is a relatively small variation within this range.

Day 4: Container 1: The values range from 120 to 125. There is a relatively small variation within this range, Container 2: The values range from 118 to 126. There is a small variation within this range.

VI.4.a Calculating Averages

using the averaging formula:

$$\boldsymbol{Avg = \frac{drain\ time\ sum\ per\ day}{number\ of\ tests\ per\ day}}$$

Where:

Avg: average drain time per day.

Number of tests per day = 4

On day 1: The average drain time for Container 1 is 123.7s, and for Container 2 is 125.5s.

On day 2: The average drain time for Container 1 is 127.7s, and for Container 2 is 124.7s.

On day 3: The average drain time for Container 1 is 122.2s, and for Container 2 is 121.7 s.

On day 4: The average drain time for Container 1 is 121.7s, and for Container 2 is 124.7 s.

VI.4.b Conclusion

Knowing the Standard Limit of **125s** ±**20s** for the drain time**:**

We concluded that Overall, the data for **each day is conformal to the standard limit, as the average drain times for both containers are within the acceptable range meaning the glue viscosity is Conformal and can be used without issues [15].**

VI.5 Visual checks of the produced cardboard panel

Results from the visual checks are compiled into the table below:

Table VI Resoults of the visual checks after the of the produced cardboard panels.

day	1	2	3
warping	Absent	absent	**present**
Washboarding	Absent	absent	absent
Glue strength	Good	good	good
crease quality	Good	good	good

Warping (curved panel) (figure 28): Warping is absent on day 1 and day 2 but becomes present on day 3. This indicates that there may be certain factors during the production process of day 3 that are causing warping in the cardboard panels. Further investigation is needed to identify the specific causes.

Washboarding (figure 28): Washboarding is absent throughout all three days, suggesting that the production process is effectively preventing this phenomenon. This is a positive outcome, as Washboarding can affect the aesthetic appearance and structural integrity of the cardboard panels.

Glue Strength: The glue strength is consistently good across all three days. This indicates that the adhesive used in the production of the cardboard panels is performing well and providing sufficient bonding.

Crease Quality: The crease quality is consistently good throughout the testing period. This implies that the folding and scoring process is being executed properly, resulting in well-defined and durable creases

VI.5.a Conclusion:

while the cardboard panels exhibit warping on day 3, other crucial factors such as Washboarding, glue strength, and crease quality remain unaffected. It is recommended to further investigate the causes of warping and implement corrective measures to ensure the production of flat and non-curved cardboard panels **[15].**

VI.5.b corrective measures

1. Adjust Moisture Content: Warping can be caused by variations in moisture content. Ensure that the moisture content of the cardboard sheets is within the optimal range during production. This can be achieved by controlling the humidity levels in the manufacturing environment or using moisture-resistant materials.
2. Enhance Drying Process: Insufficient drying time or uneven drying can contribute to warping. Review and optimize the drying process to ensure uniform drying throughout the cardboard panels. This may involve adjusting temperature, airflow, or drying duration during production **[16].**

VI.6 Results of quality tests during transformations of cardboard panels

Results from the 4 tests conducted on day 1 compiled into the table below:

Table VII Quality tests after transformation of the cardboard panels day 1

Test number	**1**			**2**			**3**		
Print quality	passed			passed			passed		
Print alignment	Slight misalignment			Slight misalignment			aligned		
Box shape	Box doesn't close correctly			correct			correct		
Cuts and creases quality	Found Cracks in creases			good			good		
Sample number	1	2	3	4	5	6	7	8	9
BCT(N)	**2110.62**	**2111.82**	**2158.59**	**2100.10**	**2285.68**	**2158.63**	**28.63**	**5839.6**	**68.58**

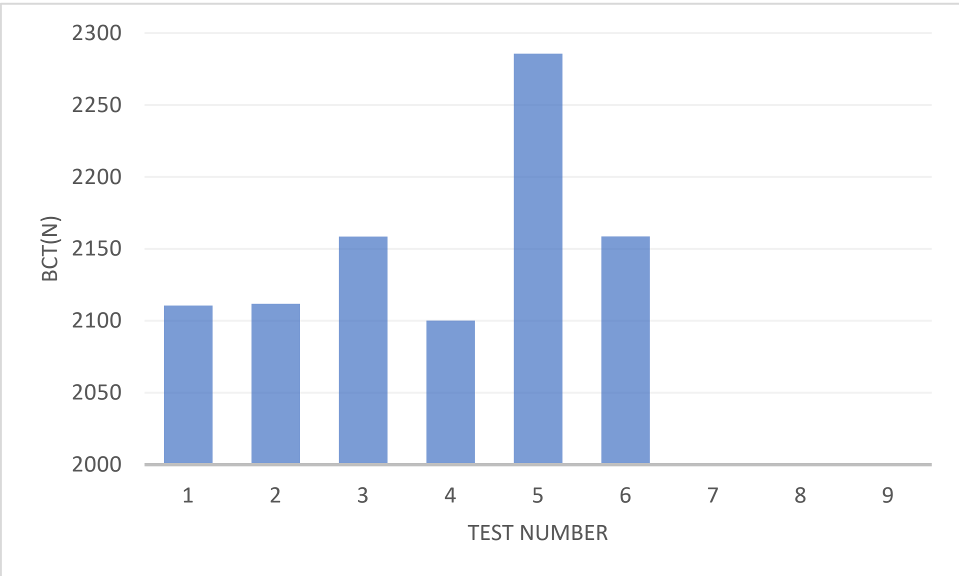

Figure 31 Clustered column representation of the BCT values on day1

Results from the 4 tests conducted on day 2 compiled into the table below:

Table VIII Quality tests after transformation of the cardboard panels day 2

Test number	1			2			3		
Print quality	passed			passed			Yellow ink washed out		
Print alignment	aligned			aligned			aligned		
Box shape	correct			correct			correct		
Cuts and creases quality	good			good			good		
Sample number	1	2	3	4	5	6	7	8	9
BCT(N)	**2115.68**	**2258.47**	**2436.75**	**2187.52**	**2136.78**	**2169.60**	**2685.67**	**2158.63**	**2144.23**

Figure 32 Clustered column representation of the BCT values on day 2

Results from the 4 tests conducted on day 3 compiled into the table below:

Table IX Quality tests after transformation of the cardboard panels day 3

Test number	1			2			3		
Print quality	passed			passed			passed		
Print alignment	aligned			aligned			aligned		
Box shape	correct			correct			correct		
Cuts and creases quality	good			Cracked crease			good		
Sample number	1	2	3	4	5	6	7	8	9
BCT(N)	**2236.69**	**2182**	**2183.08**	**2121.05**	**2115.41**	**2222.10**	**2115.64**	**2524.65**	**2067.87**

Figure 33 Clustered column representation of the BCT values on day 3

Results from the 4 tests conducted on day 4 compiled into the table below:

Table X Quality tests after transformation of the cardboard panels day 4

Test number	**1**			**2**			**3**		
Print quality	passed			passed			passed		
Print alignment	aligned			aligned			aligned		
Box shape	correct			correct			correct		
Cuts and creases quality	Found Cracks in creases			good			good		
Sample number	1	2	3	4	5	6	7	8	9
BCT(N)	**2100.86**	**1989.75**	**1998.36**	**2022.58**	**2257.6**	**2145.69**	**2174.58**	**2536.48**	**2258.60**

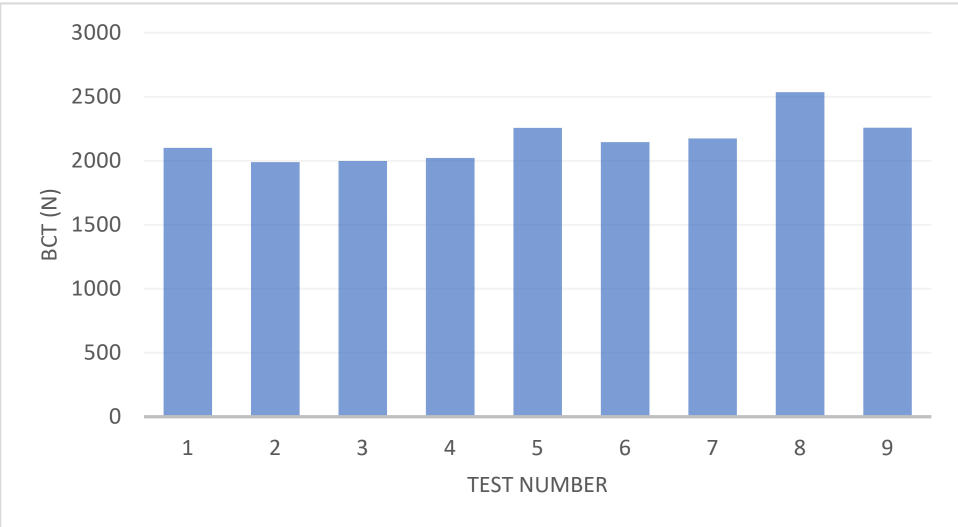

Figure 34 Clustered column representation of the BCT values on day 4

Print Quality and Alignment: Overall, the print quality and alignment of the boxes were satisfactory. The majority of the tests passed, indicating that the printing process was consistent and aligned properly with the design.

Box Shape: The shape of the boxes was generally correct, ensuring that they could be assembled correctly. This suggests that the cutting and scoring machine performed well in creating boxes with the desired shape.

Cuts and Creases Quality: While most of the tests showed good quality in cuts and creases, there were instances where cracks were found in the creases. This is a point of concern as it can affect the structural integrity of the boxes. It is crucial to investigate the cause of these cracks and take necessary measures to address and minimize them, such as adjusting the creasing process or selecting a different cardboard material.

BCT Values: On day 1, the BCT values ranged from 2100.10 to 2285.68N, Day 2 showed a wider range, with values ranging from 2115.68 to 2685.67N, and on Day 3 exhibited values ranging from 2067.87 to 2524.65N, Day 4 showed values ranging from 1989.75 to 2536.48 N.

It is important to note that the highlighted values in day 1 test 3 in red (table 7) is ignored, because these values were outputted when there was an issue with the BCT machine during the tests, the production line had to be stopped for the day until the BCT machine get fixed, which resumed on the next day.

VI.6.a Calculating Averages

using the same averaging formula from before we conclude that:

- Day 1 average: 2155.28N
- Day 2 average: 2186.05N
- Day 3 average: 2184.42N
- Day 4 average: 2132.30N
- 4-day average: 2165.85N

VI.6.b Conclusion

Based on the observations of the visual aspect obtained during this period, it can be concluded that the boxes produced are **conforming to the clients' requirements.**

Knowing the Standard Limit of **2099.38*** **± 500N** the BCT value **the produced packages consistently fall within the specified range of 2099.38*± 500N**, as indicated by the daily average and the 4-day average values. **[15]**

*The BCT value "2099.38N" is the BCT value from the 1st proposed sample accepted by the client (table 3).

VI.7 Stacking and palletization of the final product

The stacker section in figure 22 puts the final produced package in a stack of 20 and wraps them using a plastic tape, these stacks measure around 630± 10mm in length, 450± 10mm in width, 240± 10mm in height (figure) and weigh 450± 50g.

As this is a very popular and produced cardboard box type and quality, the pallet dimensions and layer number are already calculated: 7 layers for the layer number, and the pallet size is Asia Pallet with demotions of 1100mm x 1100mm **[18].** these pallets then get covered in cyclophane and a label containing a QR code that contains all the data relative to the pallet, from the number of samples in the pallet (560 samples per pallet), hour of production, client and EMB number. These pallets then get put into trucks and sent to the client **[16]**

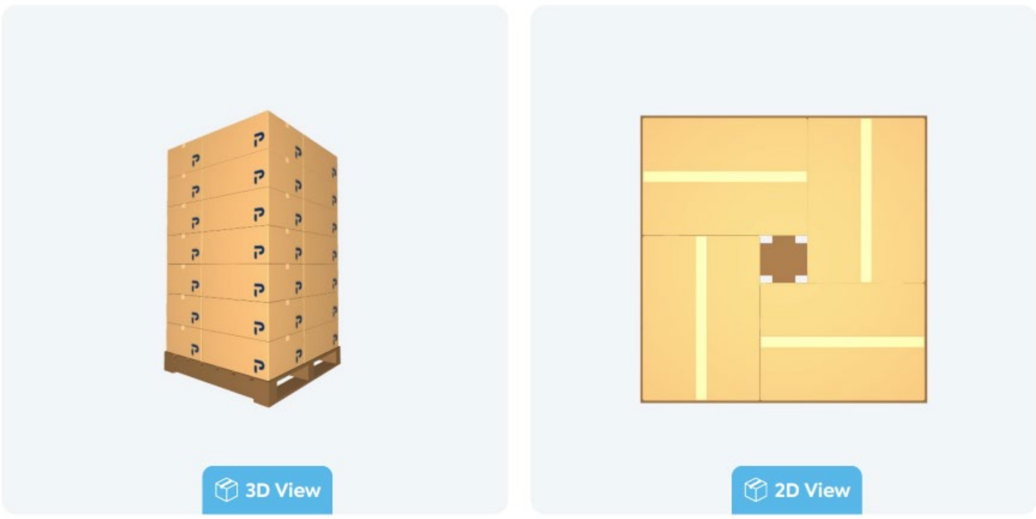

Figure 35 visualization of the palletization used in our case made using ptchronos.com/pallet-calculator

CONCLUSION

VII Conclusion

In conclusion, our internship experience at Maghreb Emballage SPA has provided valuable insights into the production and transformation of corrugated cardboard for secondary pasta packaging and answered our initial question on how this packaging material is made and transformed.

Throughout our research, we delved into the intricacies of the manufacturing process, quality testing methods, and the pursuit of sustainable packaging practices.

Where we found that:

- The paper that should be used for secondary pasta packaging is of the quality:

120BLS – 130HS – 120D

- The pallet size and number of layers that this packaging can be stacked on top.

The full manufacturing and transformation of the cardboard packaging from the raw materials to the final product.

Furthermore, we have explored the critical quality parameters and testing methods employed to ensure the integrity and performance of corrugated cardboard packaging. These include:

- assessments of print quality, alignment, box shape, cuts and creases, as well as considerations for warping, Washboarding, and glue strength of the panels.
- adhering to rigorous quality standards, we can meet customer requirements and guarantee the reliability and durability of the packaging.

Overall, our internship experience has deepened our understanding of the packaging industry and its potential for sustainable growth.

We are confident that the knowledge gained and the recommendations provided will greatly contribute to the continuous improvement of packaging efficiency, ensuring compliance with quality standards, and reducing the environmental impact of corrugated cardboard packaging in the food sector and beyond.

further research is needed to optimize the manufacturing process even further, with a focus on minimizing environmental impact. By exploring innovative techniques and sustainable practices, we can strive to enhance the overall efficiency and sustainability of cardboard packaging, ultimately contributing to a greener and more eco-friendly future.

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ATTACHMENTS

IX Attachments

1 About Maghreb Emballage:

Maghreb Emballage is an Algerian company with a rich history in the packaging industry, based in Senia and El-kerma, Oran. With over 700 employees, including a team of highly trained engineers and technicians specializing in maintenance and quality, the company prioritizes personnel development. They invest in training programs both internally and externally, ensuring that their staff remains at the forefront of industry practices.

The company's origins date back to manufacturing barrels for olive canners. In 1948, they expanded their operations to include corrugated cardboard production alongside the cooperage. In 1969, the company was acquired by seven Algerian partners, with Mr. Ahmed MERED as the current major shareholder.

Throughout the years, Maghreb Emballage has made significant investments in machinery and technology. They installed their first Spanish-made corrugator, Caballé, in 1974, which had a width of 2000mm and a speed of 40m/min, producing 6000 tonnes per year. Subsequently, they introduced a new MARTIN 1224 converting machine in 1998 and a German-made corrugator with a capacity of 310m/min in 2000. The company continued to expand its capabilities with the addition of MARTIN 618 converting machine in 2006 and a new EMBA converting machine in 2009.

In 2016, Maghreb Emballage embraced advanced technologies, incorporating BOBST 820 converting machines and BOBST DRO. The year 2021 marked the installation of another German-made corrugator with a capacity of 400m/min. Additionally, the company launched its Recovery division in the same year, highlighting its commitment to sustainability and environmental responsibility.

With a strong history of growth, technological advancements, and diversification, Maghreb Emballage continues to position itself as a leading player in the packaging industry in Algeria.

2 BLS SAICA paper Specification sheets:

BLANCO LINER SAICA

White Top Testliner C

CEPI code: 72

Exclusively available in 120 g/m², the Blanco Liner Saica is the perfect paper for economic white packaging. Sized.

saica

BLS

target characteristics

TEST	STANDARD	UNIT	BLANCO LINER SAICA
Nominal basis weight	ISO 536	g/m²	**120**
Nominal moisture index	On-line	%	8
Bursting strength	EN ISO 2758	kPa	180
		kPa.m²/g	1,5
SCT, CD	ISO 9895	kN/m	1,6
		kN.m/kg	13
COBB-60	EN ISO 535	g/m²	35
Brightness	ISO 2470 -1	%	67
b*	ISO 5631-2		-3
Roughness (Bendtsen)	ISO 8791-2	ml/min	400

guaranteed characteristics

TEST	STANDARD	UNIT	BLANCO LINER SAICA
Nominal basis weight	ISO 536	g/m²	**120**
Mean basis weight			nominal ± 3%
Nominal moisture index	On-line	%	8
Mean moisture index			nominal -1+0,5
Bursting strength	EN ISO 2758	kPa	156
		kPa.m²/g	1,3
SCT, CD	ISO 9895	kN/m	1,3
		kN.m/kg	11
COBB-60 maximum	EN ISO 535	g/m²	50
Brightness min/max.	ISO 2470-1	%	64-70
Plybond minimum	TAPPI T 833	J/m²	180
Production centre			SP

The index guaranteed values refer to the nominal basis weight

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3 DS SAICA paper Specification sheets:

DUOSAICA

testliner 2 / fluting

CEPI code: 52

High performance double use paper. Sized.

Doubles as a flute or testliner which can reduce paper stocks.

DS

target characteristics

TEST	STANDARD	UNIT	DUOSAICA																
Nominal basis weight	ISO 536	g/m²	75	85	90	95	100	110	120	125	130	135	140	150	160	165	200	230	280
Nominal moisture index	On-line	%	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
SCT, CD	ISO 9895	kN/m	1,2	1,5	1,6	1,7	1,8	2	2,2	2,3	2,4	2,5	2,6	2,8	3	3,1	3,7	4,3	5,2
		kN.m/kg	16,5	17,5	18	18	18	18	18,5	18,5	18,5	18,5	18,5	18,5	18,5	18,5	18,5	18,5	18,5
CMT 30/50, MD	EN ISO 7263	N	90	128	144	152	160	176	192	200	208	216	224	240	256	264	*	*	*
		N.m²/g	1,2	1,5	1,6	1,6	1,6	1,6	1,6	1,6	1,6	1,6	1,6	1,6	1,6	1,6	*	*	*
Bursting strength	EN ISO 2758	kPa	165	187	198	209	220	242	288	300	312	324	336	360	384	396	480	552	672
		kPa.m²/g	2,2	2,2	2,2	2,2	2,2	2,2	2,4	2,4	2,4	2,4	2,4	2,4	2,4	2,4	2,4	2,4	2,4
COBB-60	EN ISO 535	g/m²	-	-	-	-	35	35	35	35	35	35	35	35	35	35	35	35	35

guaranteed characteristics

TEST	STANDARD	UNIT	DUOSAICA																
Nominal basis weight	ISO 536	g/m2	75	85	90	95	100	110	120	125	130	135	140	150	160	165	200	230	280
Mean basis weight			← nominal ± 2% →				← nominal ± 3% →												
Nominal moisture index	On-line	%	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
			nominal -1+0,5																
SCT, CD	ISO 9895	kN/m	1,1	1,4	1,4	1,5	1,6	1,8	2	2,1	2,1	2,2	2,3	2,5	2,6	2,7	3,3	3,8	4,6
		kN.m/kg	14,5	16	16	16	16	16	16,5	16,5	16,5	16,5	16,5	16,5	16,5	16,5	16,5	16,5	16,5
CMT 30/50, MD	EN ISO 7263	N	75	111	126	133	140	154	168	175	182	189	196	210	224	231	*	*	*
		N.m2/g	1	1,3	1,4	1,4	1,4	1,4	1,4	1,4	1,4	1,4	1,4	1,4	1,4	1,4	*	*	*
Bursting strength	EN ISO 2758	kPa	150	170	180	190	200	220	240	250	260	270	280	300	320	330	400	460	560
		kPa.m2/g	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
COBB-60 maximum	EN ISO 535	g/m2	-	-	-	-	50	50	50	50	50	50	50	50	50	50	50	50	50
Production centre																			

The index guaranteed values refer to the nominal basis weight
* CMT 30/50, DM is not a valid test for weights equal to or greater than 190 g/m²

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4 HS SAICA paper Specification sheets:

HIDROSAICA
semichemical fluting type

CEPI code: 44

An excellent cost per unit of resistance for a wide range of uses, including demanding applications in industry and agriculture trays .

HS

target characteristics

TEST	STANDARD	UNIT	HIDROSAICA								
Nominal basis weight	ISO 536	g/m²	**105**	**110**	**115**	**120**	**127**	**130**	**135**	**145**	**150**
Nominal moisture index	On-line	%	9	9	9	9	9	9	9	9	9
SCT, CD	ISO 9895	kN/m	2,2	2,3	2,4	2,6	2,8	2,9	3	3,2	3,3
		kN.m/kg	21	21	21	22	22	22	22	22	22
CMT 30/50, MD	EN ISO 7263	N	210	220	230	264	279	286	338	363	375
		N.m²/g	2	2	2	2,2	2,2	2,2	2,5	2,5	2,5
CCT 30/50, DT	ISO 16945	kN/m	1,6	1,7	1,8	2	2,2	2,2	2,4	2,6	2,7
		kN.m/kg	15,5	15,5	15,5	17	17	17	18	18	18

guaranteed characteristics

TEST	STANDARD	UNIT	HIDROSAICA								
Nominal basis weight	ISO 536	g/m²	**105**	**110**	**115**	**120**	**127**	**130**	**135**	**145**	**150**
Mean basis weight			nominal ± 3%								
Nominal moisture index	On-line	%	9	9	9	9	9	9	9	9	9
Mean moisture index			nominal -1+0,5								
SCT, CD	ISO 9895	kN/m	2	2,1	2,2	2,4	2,5	2,6	2,7	2,9	3
		kN.m/kg	19	19	19	20	20	20	20	20	20
CMT 30/50, MD	EN ISO 7263	N	179	187	196	228	241	247	297	319	330
		N.m²/g	1,7	1,7	1,7	1,9	1,9	1,9	2,2	2,2	2,2
CCT 30/50, DT	ISO 16945	kN/m	1,4	1,5	1,6	1,8	1,9	2	2,2	2,3	2,4
		kN.m/kg	13,5	13,5	13,5	15	15	15	16	16	16
Production centre			SP	SP	SP FR	SP FR	FR	SP	FR	SP	FR

The index guaranteed values refer to the nominal basis weight

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5 BHS Corrugated:

BHS stands for "Biberist Heiss Stanz- und Prägesysteme,"

The origins of BHS Corrugated can be traced back to the early 1900s when it was established as a small engineering workshop in Biberist, Switzerland. Initially, the company focused on manufacturing machines for the local textile industry.

In the 1950s, BHS Corrugated recognized the growing demand for corrugated board packaging and shifted its focus to the development and production of machinery for the corrugated board industry. This marked the beginning of their specialization in the field of corrugated board production.

Over the years, BHS Corrugated expanded its operations and product portfolio. They introduced innovative technologies and advanced machinery that revolutionized the corrugated board manufacturing process. The company became known for its expertise in areas such as corrugating rolls, single-facer machines, and complete corrugators.

With a commitment to continuous improvement and customer satisfaction, BHS Corrugated gained global recognition for its high-quality products and reliable services. They established partnerships and supplied their machinery to corrugated board manufacturers worldwide, contributing to the growth and efficiency of the industry.

Today, BHS Corrugated is a leading supplier in the corrugated board industry, offering a comprehensive range of solutions, including corrugators, printing machines, and converting equipment. They continue to innovate and adapt to the evolving needs of the market, providing cutting-edge technologies and supporting sustainable practices in corrugated board production.

abstract

This thesis focuses on the production of secondary pasta packaging made of cardboard and the associated quality tests. The research examines the manufacturing process and critical parameters involved in ensuring high-quality packaging. It investigates various quality tests, including print quality, alignment accuracy, box shape, and cuts and creases. The findings contribute to sustainable packaging practices and provide recommendations for efficiency improvement. The research enhances the understanding of cardboard packaging for pasta products and emphasizes stringent quality control measures.

Keywords: secondary packaging, cardboard, pasta packaging, quality testing, production process, sustainability.

Résumé :

Cette thèse porte sur la production d'emballages secondaires pour les pâtes à base de carton et les tests de qualité qui y sont associés. La recherche examine le processus de fabrication et les paramètres essentiels pour garantir des emballages de haute qualité. Elle analyse différents tests de qualité, tels que la qualité d'impression, l'alignement précis, la forme de la boîte et les découpes et plis. Les résultats contribuent aux pratiques d'emballage durables et fournissent des recommandations pour améliorer l'efficacité. La recherche renforce la compréhension des emballages en carton pour les produits de pâtes et met l'accent sur des mesures rigoureuses de contrôle de qualité.

Mots-clés : emballage secondaire, carton, emballage de pâtes, tests de qualité, processus de production, durabilité.

ملخص:

تتناول هذه الرسالة العلمية إنتاج التعبئة الثانوية للمعكرونة المصنوعة من الورق المقوى واختبارات الجودة المرتبطة : بها .تتحلل البحث في عملية التصنيع والمعايير الأساسية لضمان توفير تعبئة عالية الجودة .وتحلل أيضًا مجموعة متنوعة من اختبارات الجودة مثل جودة الطباعة ومحاذاة الطباعة بدقة وشكل الصندوق وجودة القطع والطي .تسهم النتائج في تعزيز ممارسات التعبئة المستدامة وتوفر توصيات لتحسين الكفاءة .يعزز البحث فهم التعبئة المصنوعة من الورق المقوى لمنتجات المعكرونة ويولي اهتمامًا كبيرًا لإجراءات صارمة لمراقبة الجودة.

الكلمات الرئيسية :التعبئة الثانوية، الورق المقوى، التعبئة للمعكرونة، اختبارات الجودة، عملية الإنتاج، الاستدامة