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GREEN-LOOP

Sustainable manufacture systems towards novel bio-based materials

WP4 – Bio-plastic material production

D4.4 – Bioplastic validation trials and key findings

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GREEN LOOP Consortium Partners

	Partner	Acronym	Country
1	IDENER RESEARCH & DEVELOPMENT	IDE	ES
2	NATIONAL INSTITUTE OF CHEMISTRY	NIC	SI
3	SLOVENIAN NATIONAL BUILDING AND CIVIL E. I.	ZAG	SI
4	FRAUNHOFER GESELLSCHAFT ZUR FOERDERUNG DER ANGEWANDTEN FORSCHUNG E.V	FHF	DE
5	LABRENTA SRL	LBRT	IT
6	MIXCYCLING SRL	MYX	IT
7	NERO SU BIANCO	NSB	IT
8	GERACE MARIA CRISTINA - TERRE DI ZOE’	TDZ	IT
9	IRIS TECHNOLOGY SOLUTIONS, SOCIEDAD LIMITADA	IRIS	ES
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11	AACHEN UNIVERSITY: PROCESS CONTROL ENGINEERING / AACHEN UNIVERISITY: INSTITUTE OF SOCIOLOGY	AAU	DE
12	AUSTRIAN STANDARDS INTERNATIONAL	ASI	AT
13	INSTITUTO DE SOLDADURA E QUALIDADE	ISQ	PT
14	AXIA INNOVATION UG	AXIA	DE
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Executive Summary

The D4.4 - *Bioplastic Validation Trials and Key Findings* report marks a significant milestone in the ongoing efforts to revolutionize packaging materials within the European Union. As part of the ambitious GREEN-LOOP project, funded by the Horizon Europe program, this report outlines the development, testing, and validation of innovative bioplastic bottle closures designed to replace traditional plastic and aluminum closures.

In today's world, the urgency of addressing plastic waste has never been greater. Governments, industries, and consumers are increasingly aware of the environmental damage caused by conventional plastics, which has led to stringent regulations and a push for sustainable alternatives. The GREEN-LOOP project is a direct response to this global challenge. It aims to develop and validate bioplastic materials that not only meet the functional requirements of packaging but also align with the principles of the European Green Deal and the Single-Use Plastics Directive.

The specific focus of this deliverable is the development of bioplastic closures for olive oil and limoncello bottles, products that are not only popular in the European market but also present unique challenges in terms of packaging. Olive oil, with its sensitivity to light and air, requires a closure that ensures freshness and prevents oxidation. Limoncello, a spirit often packaged in glass bottles with decorative closures, demands a solution that is both functional and aesthetically pleasing.

The report details the comprehensive approach taken to evaluate the feasibility of using bioplastic materials in bottle closures. The development process involved extensive collaboration between MYX, which provided the bioplastic formulations, and LBRT, responsible for testing and validation.

Two primary types of closures were developed and tested:

1. **Olive Oil Bottle Closure**: This closure combines an aluminium cap with a polyethylene dispenser. The trials focused on ensuring that the bioplastic material could be effectively moulded into the required shapes while maintaining the essential properties needed to preserve the quality of the olive oil.
2. **Limoncello Bottle Closure**: A T-shaped closure made from a synthetic material combined with beech wood was developed. This choice was driven by the need for a material that could provide both the necessary elasticity and durability to ensure a tight seal while also complementing the traditional aesthetics of limoncello bottles.

The testing process was rigorous, involving mechanical and physical characterization of the bioplastic materials. Injection moulding trials were conducted to assess the moldability of the materials, while Perfilab analysis was used to validate the closures against industry standards. Special attention was paid to the biodegradability, compostability, and permeability of the materials, given their importance in meeting environmental sustainability goals.

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Table of Contents

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List of Figures

List of Tables

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Abbreviations

D. - Deliverable

EVO - Extra Virgin Olive

ISO - International Standard Organization

LDPE - Low-Density Polyethylene

MOCA - Materiali e Oggetti a Contatto con gli Alimenti (Materials and Objects in Contact with Food)

NTP - Non-Thermal Plasma

PHA - Polyhydroxyalkanoate

PHB - Polyhydroxybutyrate

PLA - Polylactic Acid

PP - Polypropylene

T - Task

WP - Work Package

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1. Introduction

The document outlines the process that led to the production of eco-friendly bottle closures. It covers the testing of bioplastic to validate its suitability for the final application, as well as the analysis that shall be done to confirm the caps' biodegradability, compostability, and permeability. The study focuses on two different prototypes: TDZ's olive oil bottle closure and TDZ's limoncello cap.

1.1. Need for eco-friendly bottle closures

The rising demand for eco-friendly bottle caps in Europe and globally stems from increasing environmental concerns and stricter regulations aimed at reducing plastic waste. The Single-Use Plastics Directive (EU 2019/904) is a key driver, targeting items like bottle caps, which frequently end up as marine litter. This directive mandates that caps remain attached to bottles to prevent pollution, pushing for sustainable material alternatives.

The European Green Deal further supports this shift, promoting a circular economy with recyclable and compostable materials. Extended Producer Responsibility (EPR) schemes also encourage companies to use sustainable materials by holding them accountable for the entire lifecycle of their products.

On a global level, initiatives like the proposed Global Plastic Pollution Treaty reflect a growing international effort to reduce plastic waste, making eco-friendly bottle caps increasingly essential.

1.1.1. Need for sustainable bottle closures for TDZ

TDZ currently uses aluminum and plastic closures for their bottles. EVO oil bottles feature an aluminium cap with a plastic inner body that seals tightly around the dispenser, preventing oxygenation and preserving the oil's quality. The limoncello bottle has a T-shaped cap made of wood and synthetic material. TDZ, together with LBRT and MYX, aims to achieve the same performance with the new eco-friendly closures and has placed no restrictions on the aesthetics or materials chosen by LBRT and MYX for the design and production of the caps.

2. TDZ target product

2.1. Olive Oil Bottle Closure

2.1.1. Target Cap and Dispenser Description

As described in Deliverable 4.1, the bottle closure for TDZ olive oil’s bottle is a combination of two elements: the cap and the dispenser.

The EVO oil caps are primarily made of aluminium, which is selected for its strength and lightweight properties. The aluminium used has a thickness of 0.21 mm and a specific weight of 2.7 kg/cm^3, ensuring durability and a strong seal. The caps have an outer diameter of 31.5 mm and a total height of 24.1 mm. Each cap, excluding the gasket, weighs 1.85 grams.

These caps are designed to withstand significant pressure, with a breaking load (Rp 02N/mm^2) exceeding 140, indicating their robustness. Internally, the caps are coated with either epoxy or polyester paint, which complies with the regulations set forth by DM21/03/73 and 90/128CEE. Externally, they are printed with vinyl paint that also meets the same regulatory standards. The caps possess physical properties classified as H12, reflecting their specific hardness and strength characteristics.

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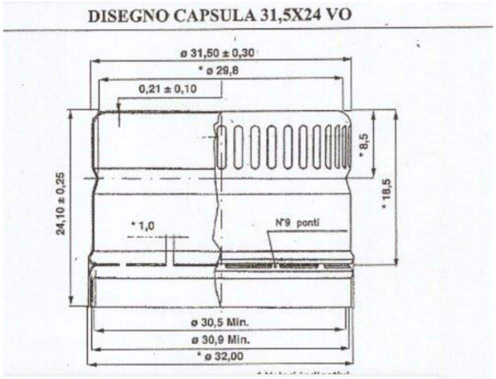

Figure 1. EVO Oil Bottle Closure

The oil dispenser is crafted entirely from polyethylene (PE). The dispenser is designed to ensure a precise and controlled flow of extra virgin olive oil (EVO), contributing to the preservation of the oil's quality. The material PE of the dispense has a specific weight ranging from 0.918 to 0.924 grams per cubic centimetre, which reflects its density and lightness. The Vicat softening point, the temperature at which the material begins to deform under pressure, is 93°C, indicating its heat resistance. The total weight of the pourer is 3.10 grams, and it is designed to withstand a deformation load of 100 to 130 kilograms when closing, ensuring a secure and reliable seal.

Figure 2. EVO Oil Dispenser

2.1.2. Olive Oil’s Bottling

In the current bottling process for EVO oil, the oil is first dispensed into bottles automatically using a dosing machine. The machine is the "BB 20" semi-automatic filling machine, designed for filling bottles with liquid food products such as wine, milk, water, oil, fruit juices, creams, and ice cream.

The operator begins by setting the desired quantity of liquid to be dispensed using the machine's touch-screen display. Once the machine is ready, the operator manually removes the cap from the bottle using a stainless-steel clamp integrated into the filling head. Next, the machine automatically extracts air from the bottle, a critical step to prevent contamination and ensure the longevity of the product. Once the air has been removed the machine dispenses the set amount of liquid into the bottle. The filling head, equipped with a pneumatic valve, controls the flow of the liquid to ensure precise measurement. After the liquid is filled, the operator replaces the cap onto the bag using the same clamp, sealing it securely.

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Throughout this process, the machine’s control system coordinates the various steps, managing the pump, compressor, and valves to ensure a smooth and hygienic operation. This meticulous process allows for consistent and reliable filling, essential for maintaining the quality of the packaged product.

Figure 3. EVO Oil Bottle

Figure 4. "BB 20" semi-automatic filling machine

2.2. Limoncello Bottle Closure

2.2.1 Substitution of Fruit Juice Bottle Closure

The second prototype prosed in the Green Loop proposal was TDZ’s fruit juice cap. However, after internal discussion between TDZ, LBRT and MYX, it was decided to choose another product of TDZ, the Limoncello.

This decision was taken bioplastic closures are not applicable due to the hot pasteurization process used for fruit juice. In fact, seal off the juice bottle by creating a vacuum within, the cap needs resistance to temperatures from 85-95 °C.

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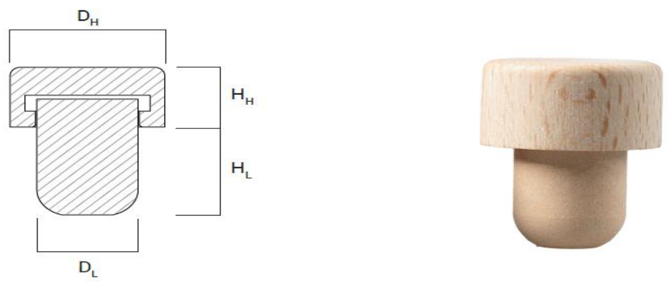
Figure 5.Fruit Juice Bottle

2.2.2. Target Cap Description

The Limoncello bottle closure is a T-shape cap. The steam is made with synthetic material whereas the glued head is made with beech. Its aspect and dimensions are described in Figure 6.and Table 1.

Figure 6. TDZ t-shape



Dimension	Value (mm)
D_H	41
H_H	15
D_L	27
H_L	20

Table 1. TDZ t-shape Dimensions

2.2.3. Limoncello’s Bottling

The bottling process of the Limoncello in done manually by inserting the cap in the bottle with no lubricant. It is pushed in the bottle through a manually handled wheel capper.

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Figure 7. TDZ Wheel Capper *Figure 8.TDZ Limoncello Bottle*

3. Material Injection Trial

As described in D4.2, the bioplastic T23089 formulated in MYX is made by PLHB, PLA and cork. In LBRT the material was first tested to verify if it was easily injectable. The samples produced testify that the material is printable, and were later on sent to ISQ to execute the mechanical and physical characterization.

Figure 9. LBRT injection trial with T23089

Table 2. outlines the technical parameters and specifications for an injection moulding process associated with a part called "Handle" using mould S00279. This process uses an electric injection moulding machine equipped with a 40 mm diameter screw and a 20:1 L/D ratio. The machine can accommodate a maximum screw volume of 176 cm^3, with the specific part's volume being 104 cm^3.

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The material used in the moulding process is specified, with a colour resembling cork. The material undergoes a drying phase at 55°C for four hours before moulding. The document provides detailed temperature settings for various zones of the machine's cylinder, ranging from 150°C to 165°C, and mentions a specific hopper temperature of 50°C.

In terms of the injection process, key parameters include an injection stroke of 105 mm and varied injection speeds. The maximum injection pressure is set at 1000 bar, though the actual pressure observed during operation is 780 bar. The holding phase applies a pressure of 400 bar for four seconds.

The cycle includes a mould closure time of 2.56 seconds, a mould opening time of 2.25 seconds, and a total cooling time of 45 seconds. The entire cycle, including other ancillary processes, takes around 65 seconds. Notably, the mould test was conducted with a single cavity due to limitations in the screw volume.

Category	Property/Description	Value/Specification
Mold Information	Mold ID	S00279
	Part Volume	104 cm³
	Number of Cavities	1
	Product Name	Handle
	Client	Not for Food Use
Machine Information	Press Number	27
	Screw Diameter	40 mm
	Screw L/D Ratio	20
	Max Screw Volume	176 cm³
	Machine Type	Electric
	Nozzle Diameter	3.5 mm
Material Information	Polymer	PLA/PHB 20 Cork
	Drying Time	4 hours
	Drying Temperature	55°C
Production Information	Part Weight	102.9 g
	Total Weight of Part Produced	102.9 g
	Number of Cavities	1
	Total Weight of Runners	10.3 g
Cylinder Temperatures	Nozzle	165°C
	Zone 1	165°C

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	Zone 2	160°C
	Zone 3	160°C
	Zone 4	155°C
	Zone 5	150°C
	Hopper	50°C
Hot Runner Temperatures	Fixed Temperature	35°C (Cold Water)
Plastification	Dosage Volume	102 cm³
	Back Pressure	50 bar
	Cooling Time	45 seconds
	RPM	150
Injection Parameters	Injection Stroke	105 mm
	Injection Speed	v1: 15%, v2: 18%, v3: 12%, v4: 12%
	Max Injection Pressure	1000 bar
	Real Injection Pressure	780 bar
Holding Parameters	Holding Pressure	P1: 400 bar
	Holding Time	T1: 4 s
Timing and Other Details	Mold Closure Time	2.56 s
	Closing Force	100 TON
	Mold Opening Time	2.25 s
	Injection Time	5.83 s
	Cooling Time	45 s
	Total Cycle Time	65 s

Table 2. Machine Parameters for Injection Trial

4. Neck of the bottles Analysis

4.1. Olive Oil Bottle Closure

LBRT analyzed the bottle and the cap of olive oil, concluding that the screw cap is a standard 31.5 pilfer-proof bottle closure.

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A pilfer-proof bottle model is carefully designed to ensure product security and consumer safety. These closures are typically made from either aluminium or plastic, with the choice of material depending on the intended use. The closure features a tamper-evident band, which breaks away when the bottle is first opened, leaving a visible indication on the bottle neck that the product has been accessed. The threaded design of the closure ensures a secure fit with the bottle, providing an airtight seal.

From a regulatory standpoint, pilfer-proof closures must comply with industry standards such as Regulation 1935/2004 / EC and Regulation 10/2011 to ensure they are safe for use with food, beverages, or pharmaceuticals. The materials used in these closures must meet specific regulatory guidelines, such as those set by the European Commission.

However, there are challenges associated with pilfer-proof closures. Ensuring compatibility between the closure and the bottle neck is critical to prevent leaks or the closure from popping off. These closures can also be more expensive to produce due to the added complexity of their design and the materials required.

Indeed, the mould used at LBRT is very complex in its design.

4.2 Limoncello Bottle Closure

For the Limoncello bottle, LBRT performed a Perfilab on it. PerfiLab is an automatic system for control of the internal diameter of the bottlenecks of bottles. Controlling the profile of Bottle bottlenecks is a parameter of important control for manufacturers of bottles, cork stoppers and wineries.

Figure 10. Egitron Perfilab

It collects values at 0º and 90º and determines whether or not the neck has ovality. Ovalization in the neck of bottles refers to the deformation of the neck's originally circular shape into an oval or elliptical shape. Ovalization of a bottle's neck can have significant implications for the integrity of the seal between the bottle

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and its closure. When the neck becomes deformed from its intended round shape to an oval one, it can lead to issues such as uneven sealing, where the closure may not fit properly, causing potential leaks or allowing air to enter, which can spoil the contents. This deformation can also result in inconsistencies in how the closure, whether it's a cork or a cap, is inserted, leading to an unreliable seal. Moreover, the uneven pressure distribution caused by ovalization can affect the ability of the closure to maintain the necessary pressure inside the bottle, which is particularly problematic for carbonated beverages or products that require airtight sealing. As a result, gases might escape more easily, leading to premature loss of carbonation or other critical gases, compromising the product's quality.

Perfilab plays a crucial role in determining the optimal fit for bottle closures by precisely measuring the steam tolerance of the cap. Once the steam properties are accurately identified trials to assess the closure's effectiveness in preventing leaks and maintaining a secure seal under various conditions, including temperature fluctuations and pressure changes, can be performed. These tests ensure that the closure not only fits properly but also performs reliably in real-world applications, safeguarding the integrity of the contents.

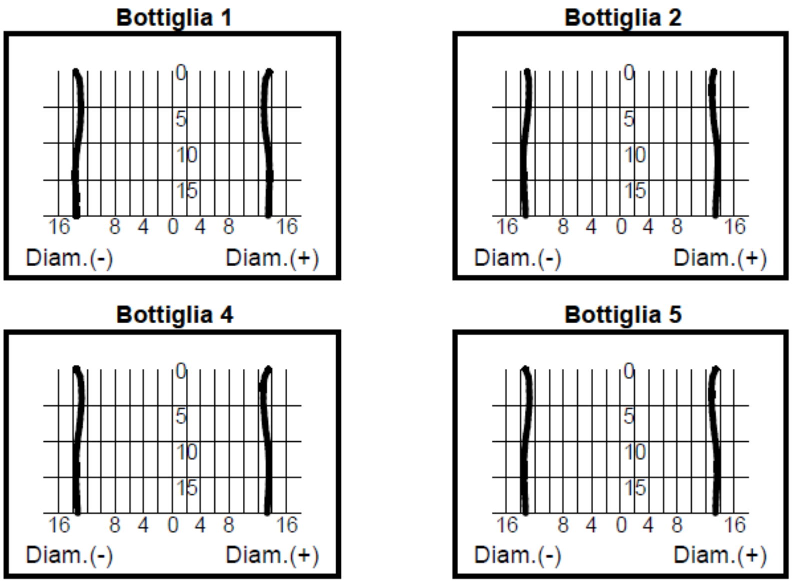

Figure 11. Profile of the 'Medium' opening (mm) - Scale 1:1

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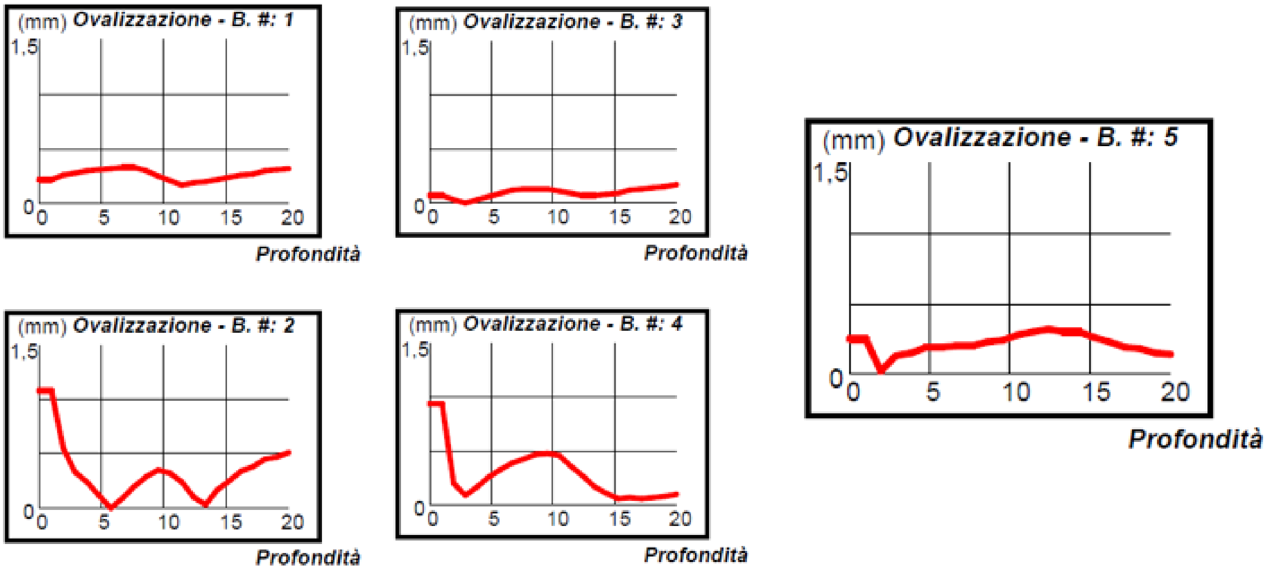

Figure 12. Ovalization

The laboratory at LBRT determined that the model of the bottle is defined as Vecchia Farmacia 500 ml, as described in Table 3.

Parameter	Value
Model	Vecchia Farmacia 500 ml
Capacity R.B. (c.c.)	540
Glass weight (gr)	350
Total height (mm)	165
Body diameter (mm)	83.8
Finish	BOCCA PROFUMO
Minimum through bore (mm)	22

Table 3. Limoncello Bottle Technical Characteristics

5. Samples Production

5.1 Bottle of Olive Oil Samples

At LBRT, several tests were conducted using MYX material T23089 (PHBH/PLA Cork) and material T23088 (PHBH/PLA). The latter formulation was selected for comparison with T23089 primarily due to injection moulding considerations. Without the cork fibers, T23088 is more fluid and easier to inject, and its purely polymeric composition makes it more amenable to printing.

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Figure 13. TDZ EVO Bottle with LBRT T23089 Cap

5.1.1 Dispenser Samples Result

With the material provided by MYX, LBRT initiated the injection moulding tests. The first component to be chosen for this test was the pourer, which is typically moulded using LDPE (Low-Density Polyethylene).

During the test, LBRT encountered significant difficulties with T23089 due to the material's characteristics. Specifically, the material demonstrated excessive rigidity and insufficient fluidity, which severely impacted the moulding process. The pourer components, intended to be produced efficiently and accurately, were difficult to process due to these issues. As shown in Figure 14. , the pieces had to be manually extracted from the mould. Unfortunately, this manual extraction led to deformation and, in some cases, breakage of the components. Additionally, the low fluidity of the material resulted in the formation of flash—unwanted excess material—around the edges of the components. This issue arose because the material required much higher pressure to fill the mould completely, which is indicative of its poor flow properties.

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Figure 14. Pourer in T23089

These difficulties suggest that the material's rigidity and flow characteristics are not suitable for the pourer component. Overall, the test results indicate that adjustments or alternative materials may be necessary to achieve successful moulding outcomes for both the pourer and screw cap components.

The rigidity is given by the PLA, and MYX is actively reformulating its percentage in T23089 to provide a softer material.

Test with T23088 went similarly, even if the material was easier to extract from the mould and to print.

Figure 15. Pourer in T23088 and in T23089

5.1.2 Screw Cap Samples Result

At LBRT, an injection moulding test was recently carried out with MYX materials, which presented some unique challenges due to their distinct processing requirements compared to our standard materials.

Firstly, the material T23089 might be too rigid the screw cap, which is typically moulded with a more flexible polymer like PP (Polypropylene) or with aluminium.

Moreover, the typical injection mould at LBRT is designed to operate at temperatures up to 190°C with a cycle time of 25 seconds. This setup is optimized for conventional materials that fit within these temperature and time parameters. However, MYX materials that were tested required a different approach. These materials need to be processed at a lower temperature of 140°C and have a cycle time that is approximately double that

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of the materials usually used. MYX tested T23089 for temperature up until 180°, however the injection moulding in LBRT burnt the material.

This is because one of the major issues encountered during the test was the design of LBRT existing mould. The current mould is equipped with a core pin system, rather than a hot runner or direct injection system. The core pin system is less suited for the longer cycle times and lower temperatures required by the MYX materials. Specifically, the core pin cools down too quickly, which disrupts the injection process. This rapid cooling leads to blockages and prevents the material from flowing correctly through the mould.

Furthermore, the limitations of the core pin system make it impossible to extend the cooling times or lower the processing temperatures without affecting the efficiency of the injection process. As a result, LBRT issues with incomplete filling, potential blockages, and suboptimal component quality.

Similarly to what happened with the pourer, the formulation T23088 gave slightly better results in terms of aesthetics of the final product.

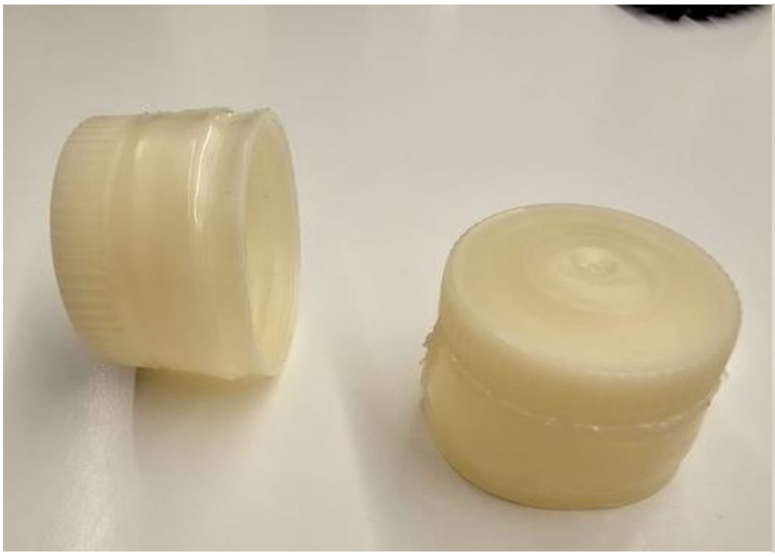

Figure 16. EVO Cap in T23089

Figure 17. EVO Cap in T23088

To address these challenges and effectively process the MYX materials, LBRT only option would be to invest in a new mould that features a hot runner or direct injection system. These systems are designed to handle the extended cooling times and precise temperature control required for these materials. By upgrading to a mould with these capabilities, LBRT would be able to achieve better processing conditions, improve the quality of the moulded components, and fully utilize the properties of the MYX materials.

However, time and costs of development make this option non-feasible for the Green Loop Project.

5.2. Bottle of Limoncello Samples

Based on the description of TDZ Limoncello bottle closure, two option were considered for the project:

1. A mono material cap made with T23089 + bioexpandent
2. A cover made with T23088 + a topping made with T23089

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5.2.1 Option 1 Limoncello Cap

The initial option involved using a bio-expandent in combination with material T23089 to create a mono-material cap. An expandent is a key additive in the production of synthetic bottle closures, offering several advantages such as weight reduction, cost efficiency, improved performance, insulation properties, and enhanced design flexibility.

Figure 18. Example of Monomaterial T-shape

To explore this option, LBRT reached out to a supplier specializing in bio-expandents for further development. However, during discussions, it was determined that this approach would not be feasible due to concerns about food safety. Although the formulation could be customized specifically for the project, the bio-expandent's food safety status could not be guaranteed. This poses a significant issue for applications involving contact with food products, where stringent safety and compliance standards are required.

As a result, this option was set aside in favour of alternative solutions that ensure both the performance of the cap and compliance with food safety regulations.

5.2.2 Option 2 Limoncello Cap

Option two explores the use of a T-shaped cap printed with a pure polymeric material, such as PHBH, PLA, or T23088. This prototype functions as a cover designed to be sealed with a medallion made from T23089.

The proposed cap design involves creating a T-shaped cover that integrates seamlessly with the medallion, forming a complete closure system. The polymer's elasticity is expected to adapt well to the contours of the bottle, providing a secure seal that prevents leakage and maintains the integrity of the limoncello. This approach aims to balance functionality with ease of use, ensuring that the cap performs reliably under various conditions.

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Figure 19. Medallion in T23089 for Limoncello Bottle

Figure 20. 3D printing of cover for Limoncello Bottle

As of now, the mould for this cap design has not been produced, which means that testing with the MYX material has not yet been conducted by LBRT. The development of the mould is a critical next step, as it will enable the production of prototypes and allow for practical assessments of the cap's performance in real-world scenarios. Once the mould is created, LBRT will be able to evaluate how well the selected polymeric materials meet the design requirements and assess their suitability for use with limoncello bottles.

6. Tests to be performed

Due to the challenges encountered with injection moulding of EVO oil bottle closures during multiple test phases, and following the adjustment made by MYX to the T23089 formulation, the testing of the final product is scheduled to commence in M25. At the same time, the mould for the limoncello cap will be developed.

Moreover, the official transition of Labrenta Srl to the Guala Closures Group, has created some delays with respect to the planned activities.

In the upcoming phase, LBRT will conduct essential food contact tests on the samples using food simulants, in strict accordance with UNI EN 13342 standards and MOCA (Materials and Objects in Contact with Food) Certification requirements. These tests are crucial to ensure that the closures meet all safety and compliance criteria for direct food contact.

Additionally, LBRT will evaluate the biodegradability, compostability, and permeability of the closures. These assessments will be carried out in collaboration with our project partners to verify the environmental impact and performance characteristics of the final product. The comprehensive testing will help confirm that the closures not only comply with food safety regulations but also align with sustainability goals and functional performance standards.

6.1. Timeline of the tests

Here is a timeline for the pending analysis:

- **Biodegradability Testing**: typically 6-12 months, depending on the environmental conditions and standards applied. It evaluates how well the material breaks down under natural environmental conditions, such as soil, marine, or landfill environments. Measures the rate of decomposition and assesses the presence of residual materials.
- **Compostability Testing:** approximately 3-6 months. It assesses whether the material decomposes effectively in composting conditions and turns into compost without leaving harmful residues. The test simulates industrial or home composting environments.

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- **Permeability Testing:** typically 1-2 weeks, depending on the testing methods and material characteristic. It measures the material's resistance to the passage of gases or liquids. Evaluates the effectiveness of the closures in maintaining the quality of the product by preventing leakage and ensuring proper barrier properties.

7. Conclusions

The GREEN-LOOP project's deliverable on bioplastic validation trials provides a clear pathway toward sustainable packaging solutions for the food and beverage industry. The successful development and validation of bioplastic closures for olive oil and limoncello bottles represent a significant step forward in reducing reliance on traditional plastic materials, aligning with global environmental goals.

The results of the bioplastic validation trials are cautiously promising. The materials developed showed excellent potential for use in bottle closures, demonstrating good moldability and sufficient mechanical strength to meet industry standards. The closures produced from these bioplastic materials successfully passed the initial rounds of testing, indicating that they could provide a viable alternative to traditional plastic and aluminium closures.

However, the trials also revealed some challenges. The most significant of these was ensuring consistent compatibility between the closures and the bottle necks, particularly in maintaining the integrity of seals to prevent leaks. This issue highlights the need for further refinement in the production process to ensure that the bioplastic closures can be reliably used across a range of bottle designs.

As the project progresses, continued collaboration among consortium partners will be essential to refine these solutions and ensure their successful implementation on a broader scale. The outcomes of this deliverable are expected to influence industry practices and regulatory frameworks, paving the way for wider adoption of eco-friendly materials in packaging.

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Annex A: List of standards applicable to the Bioplastic value chain

- **EN 13432 -** Packaging - Requirements for packaging recoverable through composting and biodegradation. Test scheme and evaluation criteria for the final acceptance of packaging
- **ISO 16620-1:2015** - Plastics — Biobased content in plastic products, polymers and additives.
- **Regulation (EC) No 1935/2004** - Framework Regulation on Materials and Articles Intended to Come into Contact with Food

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