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FEASIBILITY OF THE MANUFACTURING PROCESS OF CORK STOPPERS FOR SPIRITS USING VEGETABLE AND TEXTILES FIBERS

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INTRODUCTION

Worldwide production of caps for bottled beverages reaches figures of 20.000 millions units annually, of which approximately 13.000 millions rely on the use of cork as a sealing method. Only in Spain about 10% of the global production of caps are produced [1]. Its specific properties, including low density, very low water permeability, elastic properties, and its inert nature condition, make it the best sealant for quality wines [2]. Traditionally, cork stoppers composed of a plastic crown and a cork spike, usually agglomerated or technical, are used to seal the bottles. Cork composition is well known, and its maintenance contributes significantly to the preservation of the ecosystem [3]. The use of synthetic plastic for crown caps derived from petroleum generates well-known environmental problems; therefore, it is of great interest to seek substitutes, deepen research, and develop new products and production methods focused on this powerful industry. The increasing necessity and prevailing trend towards the utilization of sustainable resources and environmentally-friendly practices have spurred the quest for composite materials capable of substituting petroleum-based derivatives and synthetic fibers. It is within this imperative that biocomposite materials come into play. This work aims to develop alternatives to the products currently available on the market, not only in terms of design and materials but also by exploring alternative manufacturing methods such as compression molding and the possibility it offers for the incorporation of recycled materials derived from the agricultural and leather goods sectors, which hold significant prominence in the geographical region, these biocomposites entail epoxy-based matrices reinforced with plant fibers and textiles.

METHODS AND MATERIALS

The subproducts materials utilized as reinforcements in the mixtures consist of the following three types:

- **SBP (Sugar Beet Pulp):** It is the dried pulp obtained from sugar beets, where the sugar has been mechanically extracted through pressure and subsequently dried.
- **CoP (Cork Powder):** It refers to residual cork powder generated during the sanding process of cork spindles used for spirit wine stoppers.
- **TeF (Textile Fibers):** These are textile fibers obtained from scraps or pieces of chrome-tanned smooth leather.

Different samples will be prepared, each incorporating a different type of reinforcement: SBP, CoP and TeF in 350g of resin. The mixture will be carried out until the resin-reinforcement compound reaches saturation. Resin base used is Sikabiresin 75 [4] and Sikabiresin 75-1 as hardener in a 5:2 proportion. This epoxy has 18% natural resin, which makes it more appropriate for this type of sustainable materials. The thermoplastic adhesive used to bond the caps with the cork spikes is Technomelt Supra 100 PLUS -22, manufactured by Henkel, with a melting point of 190ºC. It is a food-grade adhesive recommended by the "cabezudos" cap manufacturers. The technical specifications of this adhesive by Henkel Ibérica are published in the reference (Henkel Iberica 2023).

a) b) c)

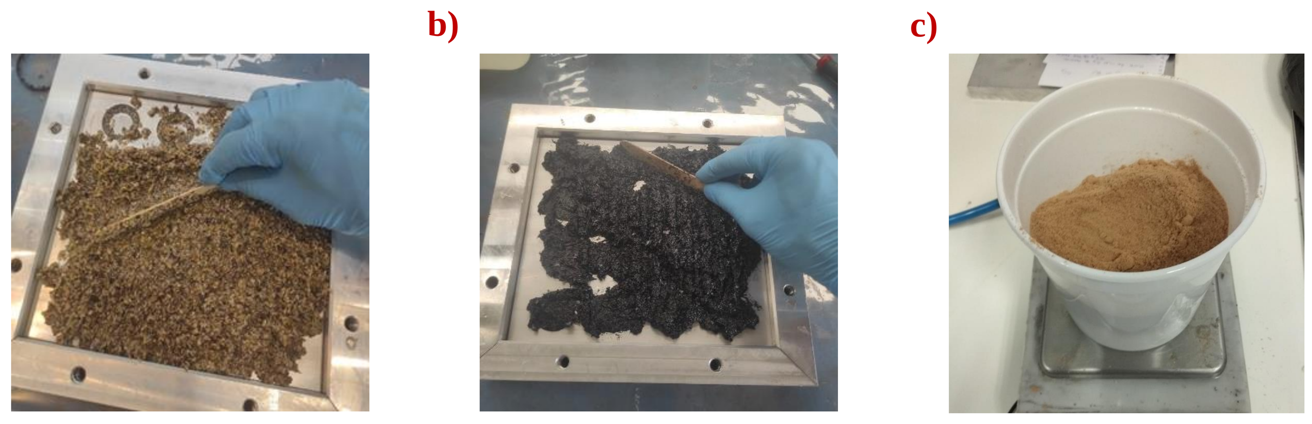

***Figure 1:** Physical aspect of the composite formed by: a) SBP; b) TeF; c) CoP*

RESULTS

In general terms, the epoxy resin matrix and reinforcement are perfectly integrated, resulting in an optimal surface finish, and no significant visual defects are observed in final products. After extraction, subsequent machining of the excess thickness, and the adhesion of the cork spikes with the hot melt adhesive , it can be verified that the result is optimal. The three samples have a quality surface finish as well as measurements and tolerances suitable for the desired function. Figure 3 displays the final products for the three different combinations.

a) b) c)

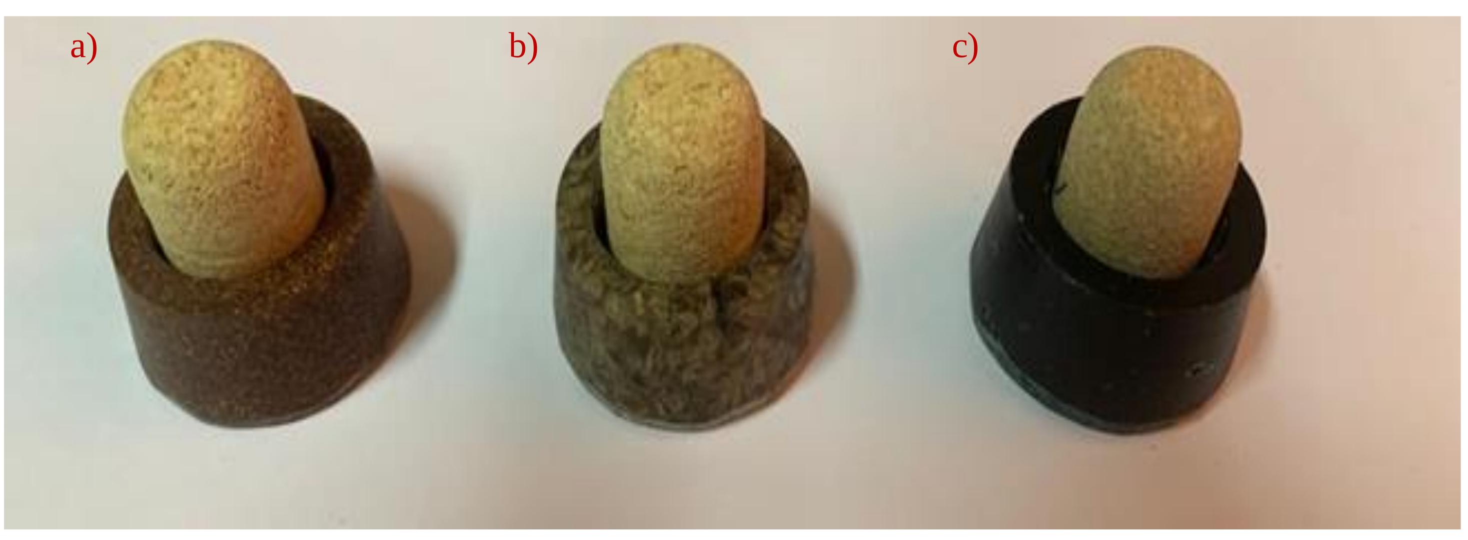

Figure 3: Final results: a) CoP; b) SBP c) TeF

DISCUSSION

Table 1. Mix parameters for samples

	Reinforce Weight [%]	Resin Weight [%]	Reinforce Weight [g]	Resin Weight [g]	Total Weight [g]
SBP	45	55	287	350	637
CoP	12	88	48	350	398
TeF	28	72	136	350	486

Under the same amount of epoxy resin, identical pressure, and temperature conditions, it is possible to achieve different weight percentages of the reinforcement material.

The proportion of epoxy matrix and reinforcement is limited by the particle size of the material, resulting in better finishes in the CoP samples with a particle size of 0.5mm. However, this also leads to lower weight percentages of the reinforcement compared to samples with larger particle sizes, such as TeF and SBP.

It has been observed that depending on the type of sample, small imperfections such as bubbles or cracks may appear in the material. The epoxy resin matrix and reinforcement are perfectly integrated, resulting in an optimal surface finish, and no significant visual defects are observed. Figure 2 shows some imperfections localizated in SBP samples.

***Figure 2**: a) Air bubbles*

***Figure 2:** b) Cracks*

CONCLUSIONS

In this study, various by-products originating from the agricultural, textile, and wine industries, which were previously considered waste materials, have been valorized. These industries hold significant influence in the geographical area where the research was conducted and have a substantial impact nationally, particularly in the textile industry on an international scale.

These materials have been blended with a common epoxy resin, resulting in a new composite with a visually striking and exclusive appearance, where the resin and reinforcement are perfectly integrated. It has been demonstrated that it is possible to provide a new purpose to materials that were previously considered waste while retaining the necessary utility and properties required to fulfill the intended function.

A new approach has been introduced aiming to save materials while simultaneously providing compounds that adhere to the principles of Circular Economy.

The ultimate objective of these prototypes is to progress towards industrial production, employing an automated casting and compaction process.

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