GLOPACK Project – New generation of bio-based and fully degradable composite food-trays made of biopolymers and fibres from agrowastes. Materials optimization for upscaled productive solutions.

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Current environmental awareness regarding wastes management has driven the development of new biodegradable materials, especially for the substitution of single use plastic items. The European Horizon 2020 innovation action GLOPACK (Granting society with LOw environmental impact innovative PACKaging) is involved in this dynamics, raising an issue which represents a strong requirement of today's food industry and society in general: how can we accelerate the transition to a circular bio-packaging economy concept? To tackle this question, this project aims at developing efficient solutions to produce biodegradable food packaging materials derived from the conversion of agro-food residues. Such an approach offers a double benefit: (i) it first creates added value to non-valorised bio-wastes and (ii) participates to the emergence of a new generation of food packaging with low environmental footprint.

Two different resources of bio-wastes are used in this project: residues from the processed fruits and vegetables industry for the production of biopolyesters (used as matrix) and solid residues from the wheat industry (used as ligno-cellulosic fillers). Mixed together through hot melt extrusion, these two raw products enable the production of fully biodegradable composites. The main challenges are to decrease the final cost of materials and to modulate their functional properties for extending the shelf life of food products, and hence limiting food wastes and losses. This productive route addresses the requirement of a circular bioeconomy concept (Figure 1), guarantying a circular use of resources.

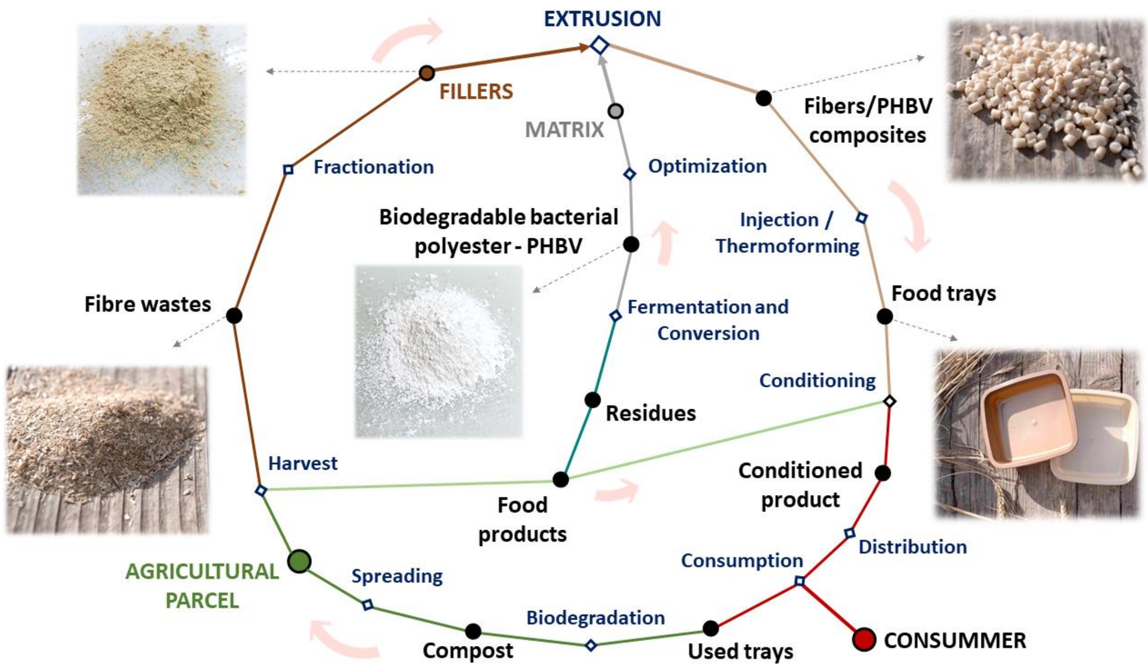

Fig.1 Production steps of fully biodegradable food trays from agro-food residues and illustration of the model of circular bioeconomy targeted in the frame of the Glopack Project

This work investigates the process optimization for large-scale production of both raw constituents and composite compounds, with the final objective of shaping by packaging converters into biodegradable trays.

In a first part, fruit wastes were fermented in specific conditions to produce poly(hydroxybutyrate-co-valerate) (PHBV): a bio-based and biodegradable thermoplastic polyester that is a promising alternative to petrochemical derived plastics displaying similar properties as several current and widely used non-biodegradable petrochemical-based plastics (Houyong, 2014; Modi, 2011; Jendrossek, 1996). Nonetheless, PHBV generally displays poor mechanical properties due to its brittle microstructure (El-Hadi, 2002; Vieira, 2011; Tanaka, 2005). As a consequence, and also because of its high thermal sensitivity, PHBV has a narrow processing window. To reach suitable performances for further conversion in packaging materials, specific conditions of production allowed to optimize valerate (HV) content, resulting in improved ductility. In this project, PHBV with 18% HV content (PHBV18) has been produced.

After production, a second part of this work was dedicated to the improvement of PHBV18 crystallization behavior. Indeed, the neat polymer is characterized by (i) a slow crystallization kinetics and (ii) a high degree of crystallinity with large crystals (Figure 2a). Thanks to optimal compounding conditions, using different type of nucleating agents (boron nitride, talc, cellulose) and adapted extrusion parameters, it was shown that crystallization kinetics could be fastened and crystals size reduced, thus enhancing material processing and ductility (Qian, 2007; Yu, 2011). By coupling optical microscopy, calorimetry and mechanical analysis, the key properties of the different blends produced in this study were analyzed to identify the optimal formulation with enhanced processability and mechanical properties. Boron nitride proved to be an excellent nucleating agent for PHBV18, and adapted concentration leads to a noticeable reduction of crystals size (Figure 2b). Glycerin was also used as external plasticizing agent in order to enhance polymer ductility.

The last part of our work was devoted to the production of ligno-cellulosic fillers from native wheat straw, and its integration to the polymer matrix. After harvest, straw was dried and ground using successive dry fractionation processes to control particle size and morphology. The different fractions were combined to the PHBV18 matrix in different proportions through extrusion and films were produced by thermocompression. The influence of both the filler size and content, as well as the introduction of additives, on the composite physico-mechanical properties were investigated. Finally, highly flexible material with good processability could be produced.

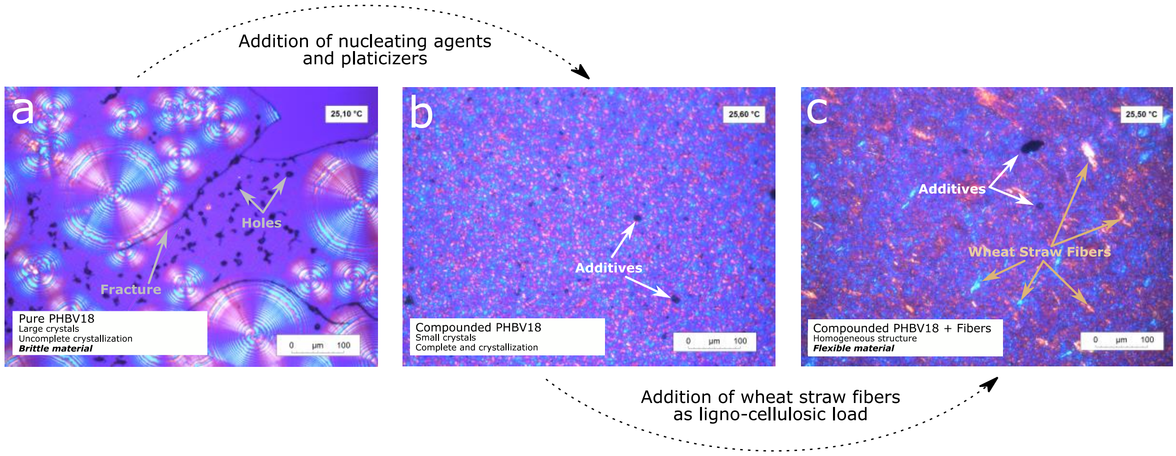

Fig. 2 Compounding steps using additives and ligno-cellulosic fillers (ground wheat straw fibres). Influence on PHBV18 crystallization, observed by polarized optical microscopy. (a) pure PHBV18, (b) compounded PHBV18, (c) compounded PHBV18-fillers composite

The present work illustrates how optimized HV content combined with adapted formulations and processing can improve PHBV18 initial properties, and participate to the development of biodegradable composites adapted for food packaging applications. This study finally represents one of part of the broader GLOPACK project and further development like smart-packaging solutions. Upscaled production systems adapted to the industry and market studies will be develop in the frame of this project. The final target is to propose an innovative and performant new family of biopackaging, which can be realistically integrated into the actual market.

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