PHASEOLIN, A NEW ECO-FRIENDLY PROTEIN-BASED BIOPLASTIC

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Petroleum-based materials have acquired more importance in our lives. However, the wide use of plastic materials has proved to be very problematic for the ecosystem representing today one of the major sources of pollution. Therefore, the scientific community is constantly looking for strategies to produce eco-friendly bioplastics that can replace petroleum-based materials, and this present work proposes a strategy that could partially replace them.

We chose phaseolin, an edible protein that represents the 50% of the vacuole protein content in common bean seeds. In its native form, phaseolin organizes in homotrimers but is unable to form longer polymers. Genetic modification of its coding sequence introduced a codon for cysteine at the C-terminal tail of the protein (named PHSL*) that leads to the formation of disulfide bridges between the phaseolin units, resulting in the production of a long polymeric chain of the protein[1]. We employed the biolistic transformation technology to introduce PHSL* gene into the plastidial genome of *Nicotiana tabacum* plants and the transformation of the chloroplasts was chosen because its oxidizing environment promote the correct production of the disulfide bridges; once the biopolymer is produced it can be used to make several products[2].

Plasticization tests revealed the formation of thin films of biopolymer, which are transparent, insoluble and elastic. We further modified the engineered phaseolin structure by inserting additional cys, in order to produce a biopolymer that could be even bigger and stronger. This new construct is being used to transform crops to take advantage of use the large amounts of waste they generate to produce bioplastics. In a circular economy model where waste becomes a resource future application of this new biopolymer in different sectors, ranging from packaging for food industry to biomedical sector as a carrier of protein-based drugs.

[1]De Marchis F, Vanzolini T, Maricchiolo E, Bellucci M, Menotta M, Di Mambro T, Aluigi A, Zattoni A, Roda B, Marassi V, Crinelli R, Pompa A. A biotechnological approach for the production of new protein bioplastics. Biotechnol J. 2024 Jan;19(1):e2300363. doi: 10.1002/biot.202300363. Epub 2023 Oct 13. PMID: 37801630.

[2]De Marchis F, Bellucci M, Pompa A. Phaseolin expression in tobacco chloroplast reveals an autoregulatory mechanism in heterologous protein translation. Plant Biotechnol J. 2016 Feb;14(2):603-14. doi: 10.1111/pbi.12405. Epub 2015 Jun 1. PMID: 26031839; PMCID: PMC11388822.