SpiderWorms: Using silkworms as hosts to produce a hybrid silkworm-spider silk fiber

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Full Abstract

Spider silk has received significant attention due to its fascinating mechanical properties. The combination of sericulture, a millennia old practice, and modern advancements in genetic engineering has given rise to an innovative biomaterial inspired by nature. Due to the solitary and cannibalistic behavior of spiders, different hosts have been investigated for the mass production of synthetic spider silk and derived products. These hosts include genetically modified goats, E. coli, alfalfa, and silkworms. The synthetic spider silk proteins produced in most of these hosts are usually smaller than native size spider silk proteins and they are difficult to purify. Further, there is no established process to manufacture fibers from the synthetic proteins, and resulting products have low mechanical properties. Unlike the other hosts, silkworms are capable of producing large quantities of a fibrous product, in a manner mimetic to spiders, and there already exists an industry to process cocoons into threads and textiles for many applications. This project focuses on the creation of chimeric silkworm-spider silk fibers through the genetic modification of silkworms. Minor ampullate spider silk (MiSp) genes were incorporated into the light chain (LC) region of the silkworm genome through CRISPR/Cas9 induced non-homologous end joining. A subset of these silkworms was cross-bred with other transgenic silkworms containing the same spider silk gene in the heavy chain (HC) region of the silkworm genome to create hybrid, dual-transgenic silkworms. Spider silk gene incorporation into the silkworm genome was verified using PCR. The transgenic silk samples showed increased mechanical properties compared to native silkworm fibers, with the strongest fibers approaching or surpassing the mechanical properties of native MiSp. Ultimately, genetic engineering opens the door to mass produce synthetic spider silk in an established organism and industry, and the results of this project demonstrate that the properties of silkworm silk can be predictably altered through this technology.