Hagworm Silk Synthesis and Strength

UtahStateUniversity
DEPARTMENT OF BIOLOGY

Joshua Corry, Dr. Xiaoli Zhang, and Dr. Justin A. Jones *Utah State University* | Student, *Utah State University*

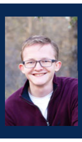
I. Introduction

When threatened, hagfish have the ability to excrete a slime that is reinforced with thread keratin fibers (TK's) as a means of defense. Even more impressive than this is the TK's themselves, which have remarkable tensile strength. Unfortunately, it is not possible to farm hagfish for the naturally-made TK's, nor is it possible to synthetically spin them in a manner that recreates their natural mechanical properties.

To circumvent these hurdles, we have turned to an alternative source of these TK's, genetically engineered silkworms (hagworms), which produce their own silk in abundance. We have placed the two hagfish TK proteins, denoted as alpha and gamma, into the silkworm's heavy chain and light chain using Crispr/Cas technology as a means to produce the two proteins.

The reason for my desire to participate in this particular internship stemmed from my fascination with microbiology, as well as my love of animals. Through this internship, I have been able to engage with both of those interests.

Joshua Corry
Utah State University
Department of Biology
jjcorry98@gmail.com



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II. Methods

There are many different steps and processes involved in the research that I have been performing, starting with the rearing of silkworms. They require a great amount of care, including specific temperatures and high humidity. Frequent cycling of their food and cleaning is necessary to keep them healthy. This is incredibly important, as if even one worm falls ill, it could quickly spread to the rest of the sericulture. Eventually, they spin cocoons, which we harvest and sort according to certain properties which they posses. After the moths emerge, we unwind the cocoons and analyze the fibers. The moths are bred according to their TKs to advance the research forward.

Figure 1 – A hagworm constructing a cocoon

III. Results

We measure both the diameter of the TKs obtained from the cocoons, as well as the mechanical properties of the TKs.
The strength to diameter ratio is then analyzed to find which combination of Heavy Chain/Light Chain is best, comparing them to the control. In addition, two combinations of Heavy Chain and Light Chain TK's are also tested, one with the Light Chain on the alpha protein and the Heavy Chain on the gamma and vice versa for the other TK.

	Diameter (Microns)		Ultimate Tensile Strength (MPa)		Energy to Break (MJ/m^3)		Elastic Modulus (GPa)	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Control	9.92	1.43	490.19	90.89	79.57	34.57	6.47	1.66
LC-Alpha	10.49	1.5	541.17	103.51	112.17	39.54	6.81	1.48
LC-Gamma	10.62	2.74	496.61	170.81	112.55	59.47	9.19	1.96
HC-Alpha	11.29	1.57	497.12	136.05	108.68	47.80	6.10	2.40
HC-Gamma	11.26	2.05	537.75	105.56	142.82	53.44	8.91	2.02
LC-Alpha + HC-Gamma	10.42	1.23	547.92	137.3	109.22	53.00	8.45	1.41
LC-Gamma + HC-Alpha	10.29	1.33	504.85	96.64	83.86	37.11	9.06	1.83

IV. Conclusions

The uses for the hagworm silk are numerous, including medical equipment, military uses, and clothing. All TK's from the hagworms have proved more durable or equal to that of the fibers from the control silkworms, but also larger in diameter and elastic modulus (aside from the HC-Alpha). The most interesting portion of this data is the fact that the LC-Gamma TK, while not the thinnest recombinant TK, has the most favorable strength to diameter ratio, while also bearing the highest elastic modulus overall. One interesting point to consider is the fact that both combination TK's had very high tensile strengths yet required less energy to break than other TK's.

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