Silk From Milk?

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Weighing in at 30 pounds, it is hardly a vest that is worn for comfort. You won't find it hanging in your nearest clothing store in shades of black, brown, or red. Instead, you will most likely see it in your favorite shade of camouflage. While many envision vests lined with wool or fleece, this particular vest is lined with woven Kevlar fiber and heavy ceramic plates. And while it may not keep you warm during the next cold spell, it could just save your life. In fact, it has already saved the lives of countless American soldiers.

The Improved Outer Tactical Vest, provided to American soldiers by the US Department of Defense is the strongest and lightest weight jacket ever made. It is strong enough to stop an AK-47 from causing serious damage and can stop the bullet of a 9mm handgun coming at you at 1,400 feet per second. However, even with modern advancements reducing the jacket's weight to 30 pounds, many soldiers still report that the shear weight of the vest restricts their movement in combat situations.

Scientists at the University of Wyoming, with support from the United States Air Force Office of Scientific Research, have genetically engineered a goat that may solve this problem. Through the

implantation of a single spider gene into the egg of a goat, researchers have created a goat that is able to produce spider silk in their milk. Spider silk is stronger than steel by weight and lighter than Kevlar, which is currently used in protective vests. After the spider silk is removed from the goats' milk, it is used to create bulletproof vests that are lighter and more flexible than their traditional counterparts.

At one-tenth the thickness of a strand of human hair, spider silk is a miraculous material. Just look out your window after the next rain shower and notice the thin strands of spider silk holding water droplets many times their size. Spider silk, in particular dragline silk, which spiders use to create the outer rims of their webs as a safety bungee, is the strongest natural fiber known in science. In fact, a strand of spider silk the size of a pencil has the strength to stop a Boeing 747 airplane. Scientists are interested in using this silk for everything from bulletproof vests to surgical sutures.

But if this silk is already produced by spiders, why aren't scientists able to harvest it in large quantities? The problem lies within the natural tendencies of spiders. When large amounts of spiders are combined in a small space they revert to cannibalism and are unable to

produce useful amounts of natural spider silk. This is where goats fit into the picture.

Researchers at the University of Wyoming first discovered and mapped the gene responsible for spider silk in 1989. Subsequently, the gene was isolated and sequenced to determine the code of the DNA. In 2000, a Canadian firm called Nexia Biotechnologies purchased the licensing rights of the gene-isolating technology. They inserted the spider silk gene into goat DNA in such a way that the spider silk protein is only reproduced in the mammary glands of the goats. The goats are then able to produce milk that contains the spider silk protein. These so called "spider goats" are actually 1/70,000th spider.

However, with only four legs instead of eight, these goats are unable to spin the webs themselves. This is where cutting-edge technology turns the milk into silk. Once the goats are milked, their milk is placed into a centrifuge-like machine that spins the milk at a high rate of speed. The milk is then separated by weight and the fats and creams are removed. The remaining liquid contains the spider silk protein. With the addition of certain salts, the protein is precipitated, becomes solid, and can be removed from the liquid.

Once the protein is removed from the milk, it undergoes a process called "wet extrusion" where it is dissolved in a water-based solution. The solution is forced through a very small opening, creating a stream of liquid that begins to harden in the presence of air. For the final process, the stream is dipped in alcohol to further solidify the fibers and remove excess water. When this is completed, scientists are left with a continuous strand of spider silk.

According to Randy Lewis of the University of Wyoming, "While promising, the yield is still low. A gallon of milk may have only 60 grams of silk, which means that it would take about 600 gallons of milk to make one bulletproof vest." However, the United States Air Force and Army are very optimistic about the possibilities of spider silk produced from goats and have provided several grants to the University of Wyoming for their continued research.

Goats may have been the center of research thus far, but Lewis and his team have also experimented with introducing the spider silk gene into alfalfa. With higher protein levels than goats' milk, Lewis believes that alfalfa could make higher yields of the spider silk protein as well. The remaining alfalfa, after the protein is removed, could potentially be used for ethanol or a dried feed for livestock. Another

benefit to using alfalfa is the fact that the plant has no wild relatives, preventing cross-pollination with another crop.

While the strength of spider silk has attracted the attention of the military to produce bulletproof vests, it has also stirred curiosity in the medical community. With an enormous demand for strong, elastic and biodegradable material, medical researchers are experimenting with spider silk to produce artificial tendons and ligaments. Ultra-thin and biodegradable sutures for eye and neurosurgery may also be created from spider silk.

With close to 300,000 American soldiers stationed overseas, agricultural scientists are using biotechnology, not for the advent of novel animals, but instead for the protection of our troops. While USDA guidelines suggest that three eight-ounce servings of milk per day may strengthen your bones, three servings of goat's milk may just save your life!

Bibliography

Callier, M. (2008). *Artificial Spider Silk Research Could Improve Body Armor, Parachutes*. Air Force Print News Today.

Chase, S. (2007). Spider Gear. Retrieved on February 8, 2010, from http://www.sciencentral.com/articles/view.php3?type=article&article_id=218392951

Chung, C. (2003). Teaching Goats to Make Spider Silk. Retrieved on February 8, 2010, from http://www.carleton.ca/catalyst/2003/s2.html

Ehrenberg, R. (2008). *Silk*. ScienceNews, Vol.174 #11, p. 24.

Inman, M. (2008). Glass Chip Spins Silk Just Like a Spider. Retrieved on February 8, 2010, from http://www.newscientist.com/article/dn13790

Lewis, R. (2010). Personal Interview. Conducted on March 30, 2010. Wyoming State University.

Stephen, W. (2000). Scientists Weave Spider Silk Into New Bulletproof Vests. National Defence ISSN: 0092-1491.

Zenk, P. (2008). *Surrogate Spider*. Hay and Forage Grower