NC STATE UNIVERSITY
Department of Textile and Apparel, Technology and Management

A COMPARISON OF NATURAL AND SYNTHETIC YARNS IN COMMON KNIT FOOTWEAR STRUCTURES

Zoe Newman
North Carolina State University Wilson College of Textiles

Introduction
Microplastics from runoff are commonly ingested by fish and other aquatic organisms as they are confused with food. Microplastics come from products such as plastic containers and bottles. Humans created plastics, and have been using them as yarns in the textile industry for decades. The worldwide consumption of synthetic apparel and accessories has increased the release of microplastics into the environment. The textile industry has used synthetic fibers for their inherent strength, durability, and low cost. However, the environmental crisis and climate change movement has demanded the industry to reconsider their raw materials and develop sustainable initiatives. Many companies have instituted the recycling of plastic bottles as yarns used in products. While the recycling of polyester yarn is a step in the right direction for the industry, the microfibers will ultimately reach a degree of processing in which they will be unable to be recycled again - resulting in waste at the end of the product life cycle. Thus, we must focus on developing a completely biodegradable shoe, otherwise the waste cycle will not end. The integration of hemp fiber into the knit footwear industry may contribute to the development of a completely biodegradable shoe. Currently, the majority of hemp fiber production is located in China and imported into the United States. Hemp has been outlawed in the United States due to its confusion with marijuana, however industrial hemp has a different THC content than marijuana, thus it is not capable of producing any psychoactive effects. The 2018 and 2019 consecutive introduction of the Farm Bill and North Carolina Senate Bill 315 officially authorized and regulated statewide hemp farming. North Carolina has the appropriate climate to grow this fiber, and in particular, North Carolina State University is well positioned to research this fiber with partnerships between the Wilson College of Textiles and the College of Agriculture and Life Sciences. The inclusion of hemp in the textile industry will allow for large strides in the United States as, creating economic development and sustainable solutions in our future.

Sustainable Footwear
Sustainability in the footwear market has increased since the 2012 introduction of Nike’s Flyknit sneaker and the Adidas Primeknit shoe. The U.S. Department of the Interior reports 300 million pairs of shoes get thrown away every year, eventually ending up in landfills (Wall & Ma, 2018). The introduction of knit shoes to the market allow for streamlined processing, resulting in less cut-and-sew while simultaneously reducing waste in the footwear industry. The effect is a reduction of waste by approximately 80% (Peters, 2015). The yarn for footwear must present robust properties with respect to weight, abrasion resistance, and strength. Research for the development of sustainable alternatives to synthetic fibers must be conducted in order for progress to be made in the industry. This study evaluates knit structures for sustainable footwear using natural yarns, specifically focusing on hemp. The intention is that the final fabrics may be integrated into fashion, shaped footwear uppers.

Methods
Three different common footwear structures are evaluated for their physical attributes using sustainable yarns and environmentally-conscious product development (Figure 5). Then, knit structures are developed from common knit structures found in the footwear industry (Figure 6). The structures are evaluated for their yarn content, burst strength, tenacity, weight, thickness, air permeability, abrasion resistance, moisture regain and fabric elongation. While current testing parameters for footwear are internal to many companies and not published, the array of tests covers many important considerations in footwear development. The fabrics were developed using the Shima Seiki APEX Software.

Research objectives included comparing existing footwear products for their contribution to sustainability in the textile industry, developing novel knit structures with hemp yarns, analyzing existing footwear fabrics against hemp-rich fabrics, and evaluating hemp as an alternative fiber to synthetic yarns. The yarns used in this study may be seen below in Table 1, while the fabrics developed may be seen in Table 2.

Hemp provides the greatest degree of air permeability and moisture regain attributes. A combination of appropriate knit structures and natural fibers allow for desirable properties to be achieved. While fabric elongation, burst strength, and abrasion resistance were not desirable, there is room for improvement with the development of stronger knit structures and different yarn sizes. Waste can be further reduced through the integration of natural fibers in footwear through careful placement of certain yarns, integration of intimate blend yarns, and the use of possible compositions made from hemp. The integration of natural yarns into footwear will allow for a more friendly contribution to the environment and our ecosystems.

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References