

The Development and Customer Acceptance of Shoes with Soles Made from Mushroom Mycelium Composite

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In 2018, World Footwear (2019) reported that 24.2 billion pairs of shoes were produced and the U.S. Environmental Protection Agency (2020) estimated that over 9 million tons of footwear and clothing were landfilled the same year. The current global market for sustainable footwear is valued at \$7.5 billion and is expected to grow by a compounded annual growth rate of 5.8% in the next 7 years with the main market share segments in men's footwear, non-athletic footwear, and in the Asia Pacific region, mainly China and India (Grand View Research, 2020).

The use of recycling and biodegradable techniques and the concept of eco-consciousness are popular sustainability innovations in the footwear industry (Grand View Research, 2020). In response to this, researchers have developed biodegradable shoe soles from a combination of mushroom mycelium, chicken feathers, and other natural ingredients (Silverman, Cao, & Cobb, 2020) and one pair of shoe prototypes using the biodegradable materials as the mid-soles (Tang, Silverman, Cobb, & Cao, 2018). When consumers are finished with their product, they can toss it into compost bins or even lay it down to rest in their backyard, which follows McDonough and Braungart's (2002) Cradle to Cradle design framework.

The purpose of this research was to develop new shoe soles and shoe prototypes using a biodegradable and sustainable material made out of the King Oyster mushroom mycelium and evaluate the customer acceptance of biodegradable shoe soles made from these materials. The shoe sole biocomposites were developed following a previous study (Silverman et al., 2020). The King Oyster mushroom sawdust spawn was mixed with chicken feather, flour, while husk psyllium, nonwoven textile mat made from waste natural fibers, and water. The mixed ingredients were formed into shoe-shape molds and placed in a temperature-controlled chamber set at 25°C and an 80% humidity for about 14 days. The composites were then placed in a heating chamber at approximately 90°C for two hours to evaporate any moisture and kill off any living fungus. The composites were wrapped with double contour espadrilles rope made from recycled canvas and jute thread as the shoe sole. Using cotton fabric as the upper, the Espadrille platform-style slip-on shoe prototypes were developed as in Figure 1.

The researchers conducted a survey to evaluate the customer acceptance of the shoe prototypes. The researchers put the picture of shoe prototypes and detailed description of the mushroom mycelium composite midsole and other natural, biodegradable components in the shoe prototypes in the survey. The survey intended to identify the primary target market of the shoe prototypes. The survey questionnaire includes Likert Scale questions, multiple choice questions, and open ended questions asking for the participants' opinion on the product. The survey was conducted online via Qualtrics. Amazon Mturk was used to recruit participants and

each participant was compensated \$1 for participating in the study. Statistical analyses were conducted using JMP statistical analysis software.

In this study, there were 243 total participants who validly completed the survey. Among these participants, 190 from the USA, 50 from India, one from Ireland, one from Singapore, and one person did not disclose his/her country. There were 127 males, 114 females, and two persons did not disclose their gender. The survey t-test results are summarized in Table 1. The participants liked the new sustainable footwear and likely to purchase it (both null hypotheses of Mean = 3 were rejected). Indian consumers significantly more like the product and more likely to purchase than the U.S. consumers (The null hypotheses of India mean = USA mean for both questions were rejected). There was no significant difference between males and females on both questions of “like the product” and “likely to purchase it” (The null hypotheses of Male mean = Female mean for both questions were not rejected). A vast majority of the participants selected “Eco-friendly/sustainable” (122 participants, 50.2%) or “biodegradability” (82 participants, 33.7%) as the feature that they like the most about this new product.



(a) Shoe prototypes (b) The mycelium composite midsole
Figure 1. Shoe prototypes with mushroom mycelium composite as midsole

Table 1. Statistical results of participants’ opinion and purchase intention of the new product

Questions		N	M±SD	p-values of t-tests	
Based on appearance and description, how much do you like or dislike this new product?	Total	243	2.41±1.17	H0: Mean = 3, p-value < .05	
	Countries	India	50	1.70±0.71	H0: India mean = USA mean, p-value < .05
		USA	190	2.60±1.20	
	Gender	M	127	2.44±1.19	H0: Male mean = Female mean, p-value = .63
F		114	2.37±1.15		
If price were not a factor, how likely or unlikely would you be to buy this new product?	Total	243	2.70±1.29	H0: Mean = 3, p-value < .05	
	Countries	India	50	1.62±0.75	H0: India mean = USA mean, p-value < .05
		USA	190	2.98±1.27	
	Gender	M	127	2.74±1.24	H0: Male mean = Female mean, p-value = .52
F		114	2.64±1.25		

Note: 5-point Likert scale: 1=most like or very likely, 3=neutral, 5=most dislike or very unlikely

In conclusion, a biodegradable shoe sole and shoe prototype was developed and consumers' acceptance of the product was evaluated. Survey participants, especially participants from India, liked the product and were likely to purchase to product, mainly due to the eco-friendly and biodegradability features. Currently, the researchers are conducting wear tests to understand the walkability and comfort of the prototype shoe.

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